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THE SAN SALVATORE ELECTRIC MOUNTAIN RAILWAY.

A PICTURESQUE ITALIAN RAILWAY.—[See page 216.]

CHEMICAL ELEMENTS.*

THEIR CLASSIFICATION.

BY PROF. H. E. ARMSTRONG.

The recognition of certain properties, the association of certain ideals with the several elements, is a necessary step in classifying the elements in accordance with Mendelejeff's great generalization—or rather it may be said to be both involved in and an outcome of Mendelejeff's conception.

Until recently our difficulty was to understand the relationship of the metallic and the non-metallic elements; now we are confronted with another problem—that of the existence of inert "paraffinoid" elements. It is commonly assumed that these are monatomic, but the evidence on which this assumption is based is absolutely unconvincing, and would be generally admitted to be so were we in the habit of looking before we leapt to conclusions. Assuming that the elements are compounds, the formation of inert compounds does not appear to be out of place, in view of the existence of practically inert hydrocarbons. But, on the other hand, in view of the properties of nitrogen, which is one of the most active of substances in the monatomic state, although an inert gas in the diatomic condition, it may well be that the inertness of helium and the other members of the argon group is also simulated. Sir James Dewar's observations have shown that helium and charcoal have no inconsiderable affinity at the boiling point of the former, which is within five degrees of the absolute zero, the molecular heat of absorption (apart from that due to liquefaction) of helium at that temperature being apparently as high as about sixty calories. The proof he has also given that helium alone does not convey an electric discharge is also of significance since the passage of a discharge through it under ordinary conditions is an indication that it can be included with other substances in a conducting system. Such evidence as there is therefore points to the elements under discussion being different from the others only in the degree of stability of their molecules.

Of late years the difficulty of classifying the elements has been increased rather than diminished, not merely because of the discovery of the inert gases but also on account of the apparent impossibility of ordering the position of an element such as tellurium in accordance with its atomic weight. There appears to be little room left for doubt that the value cannot be far removed from that of iodine; it should be considerably lower. It may be pointed out that the accepted value of selenium is closer to that of bromine than would be expected if a relationship were maintained corresponding to that between chlorine and sulphur. It would seem that Mendelejeff's original conception of the elements as a simple series in which the properties are periodic functions of the atomic weights must be abandoned in favor of some more comprehensive scheme. From the chemist's point of view, it is impossible to abandon the guiding principle underlying the arrangement in family groups, which dates back to Dumas; perhaps insufficient attention has been paid in the past to the maintenance of this principle.

Taking into account this principle, it is impossible to arrange a long series of elements such as the rare earths continuously in order of atomic weight, as they would be brought into every family in the table by such a procedure; the difficulty has been got over by Brauner, who has proposed to arrange a large number of the rare earths in a single vertical series under barium. Bilitz has made a similar proposal.

The principle had been advocated by me previously in an article written for the Encyclopedia Britannica.†

In the arrangement I have proposed, it is not only assumed that there may be as many as sixteen vertical series of elements of which the elements from hydrogen to oxygen are initial terms, some series being at present unrepresented, it is also suggested that groups of elements occur in perhaps four of these series, numbers 4, 8, 12, and 16, the largest being that of the so-called rare earths in series 8.

The principle which is assumed to be in operation is that which is so clearly manifest in the case of hydrocarbons: successive vertical series of elements correspond to successive isologous series of homologous hydrocarbons. In the case of the hydrocarbons, the passage from one isologous series to another often takes place from a term several places removed from the origin of the series—for example, from benzene, C_6H_6, which may be regarded as primarily a derivative of hexane, to naphthalene, $C_{10}H_8$, which is not an immediate derivative of benzene but of butylbenzene. It is conceivable that at the genesis of the elements a process was at work corresponding to that by which a hydrocarbon such as naphthalene is derived from benzene, and by which the former then serves in turn as the point of departure for more complex hydrocarbons of other series. There is no reason, from this point of view, why progression should not take place along a particular line and that terms should exist in a series through which this line passes but below it—for example, that antimony and iodine may bear a direct linear relationship, but that tellurium, instead of being the element in the progression series in the oxygen group, is a homologue of greater weight. The same view may be taken of selenium. In this way, it would be possible to maintain selenium and tellurium in the oxygen-sulphur series, from which they cannot well be separated, while retaining Mendelejeff's conception of a genetic relationship along the series. The only departure involved is in assuming that instead of forming a single linear series ascending regularly in spiral progression—a series which can, as it were, be strung on a single spirally-wound cord—the elements closely simulate a series of homologous isologous hydrocarbons. From this point of view, it is easy also to understand that some vertical series are unrepresented.

In discussing the chief attributes of the elements none is so difficult to deal with as that of valency, using the term in the broadest possible sense, not merely as indicative of the number of units of affinity but as including the, at present, all but incomprehensible problems of residual affinity and elementary character. I discussed the subject somewhat fully in my former address, dwelling especially on the properties of negative elements and their power of acting as linking agents; this view has met with ample confirmation in the interval, and will, I believe, be found to be of wide application in the future. I have already referred to the manner in which it is exemplified by silica.

The greatest advance in the discussion of the problems of valency in recent years is that made by Barlow and Pope, as their method of treatment is one which applies to solid substances—the correlation of structure with crystalline form which it effects promises to be of far-reaching importance.

Apart from hydrogen, carbon is the one element of certain character, always acting as a tetrad—its affinities may be only incompletely satisfied but they are always exercised, it may be supposed, even in ethenoid and similar compounds; carbon monoxide apparently is the only exception to this rule, its relative inactivity being one of the most puzzling enigmas of our science, especially as the oxide becomes one of the most active of known substances when only two atoms of hydrogen are added to it. Most other elements (non-metallic) seem to vary in valency, the valency beyond a certain minimum being dependent on the nature of the association. Of late years, attention has been directed in particular to the quadrivalency of oxygen in many of its compounds.

The quadrivalency of sulphur in substances such as trimethylsulphonium iodide, Me_3SI, having been proved to demonstration by the production of optically active compounds of this type (Pope and Peachey), it can no longer be supposed that in such cases we are dealing with compounds in which the negative constituents of the parent molecules are conjoined, e. g., $MeI : SMe_2$. And yet we must contemplate the existence of such compounds as possible—in the case of nitrogen, for example, as ammonia must be supposed to form the compound $NH_3 : OH_2$ in preference to the hydroxide $NH_4 . OH$, the latter being only a very minor constituent, the former the major component of the aqueous solution of the gas; hydrogen chloride, on the other hand, appears only to afford one product with ammonia, viz., $NH_4 . Cl$. The existence of such differences affords clear proof in the case of the non-metallic elements other than carbon that valency is not merely a variable but also a reciprocal or dependent function.

There is no reason to suppose that hydrogen ever acts otherwise than as a simple monad; and the behavior of the alkalies and alkaline earths in salts would seem to justify the conclusion that they have no tendency to vary in valency, were it not for the existence of well-defined non-volatile hydrides of these metals which are clearly substances of some degree of molecular complexity. Such compounds are illustrations of the difficulties which surround the subject. It has long been clear that the exhibition of the higher valency by an element is a process of a different order from that manifest when it exerts only its lower proper valency measured in terms of positive radicles such as H or C_nH_{2n+1} radicles. What that difference is we are unable at present to decide—carbon (together with silicon) differs from almost all other elements, especially in combining with hydrogen and analogous radicles to the extent of its maximum valency.

The proposition I made in 1888 (Phil Mag., Series V, 25, 21) that the valency lines should, in some cases, be represented as passing through the atom, so that each is capable of acting in two directions, is the only consistent mode of expressing varying valency which has been devised, the only one, moreover, by which attention is directed to the great difference.

In many cases probably there has been a tendency to exaggerate the valency value—in the case of chlorine, for example, in assuming that it functions as a heptad in the perchlorates. In this and many other instances, it suffices to assume that the chlorine and oxygen atoms are united in a closed ring, the chlorine functioning as a triad. Some such explanation will doubtless be given of the structure of the metallic ammonias and similar compounds. The co-ordination values introduced by Werner serve only to establish certain empirical relationships and are useful for the purposes of classification. The perhaps more rational plan of dealing with such compounds suggested by Abegg has a similar value.

It is to the advantage of the hypothesis formulated by Barlow and Pope that the elements are represented as of constant valency in so far as their relative volume spheres of influence are concerned—the compound in which the higher valency is manifest being derived from that of lower valency by the opening out of the close packed arrangement and the insertion of certain new elements; but the fact that in such cases the volume is altered not in one direction alone in the crystalline structure but proportionately in all directions would seem to show that the volume sphere of atomic influence does actually change; the change is one, however, which affects all the atoms in the complex proportionately.

At present, unfortunately, our methods of treating the problems of valency are such that we cannot in any way give expression to the energy side of the phenomena.

Of late there has been talk of electrons in this connection, but what is said is little more than superficial paraphrase, in the advanced scientific slang of the day, of the ideas which have long been current. When, following Odling, we represent valency by dashes written after the elementary symbol, we give clear expression by means of a simple convention to certain ideas that are well understood by all among us who are versed in the facts; to speak of electrons and use dots instead of dashes may serve to mislead the unwary, who hang on the lips of authority, into a belief that we have arrived at an explanation of the phenomena, but those who know that we have reached only the let-it-be-granted stages and who feel that the electron is possibly but a figment of the imagination* will remain satisfied with a symbolic system which has served us so long and so well as a means of giving simple expression to facts which we do not pretend to explain. Not a few of us who listened to the discussion of the nature of the atom at Leicester could not but feel that the physicists knew nothing of its structure and were wildly waving hands in the air in the endeavor to grasp at an interpretation which would permit of mathematical interpretation being given to the facts. Until the credentials of the electron are placed on a higher plane of practical politics, until they are placed on a practical plane, we may well rest content with our present condition and admit frankly that our knowledge is insufficient to enable us even to venture on an explanation of valency.

Aluminium paint is made by blowing air or gas through molten aluminium while it is setting, and at the same time stirring violently. This forms a spongy or granulated metal that is easily pulverized. The powdered metal is sized and polished.

* Abstracted from a paper read before the Chemical Section of the British Association for the Advancement of Science.

† Cf. Roy. Soc. Proc., 1902, vol. lxx, pp. 86-94.

* In my opinion the experimental evidence is in no way satisfactory. It appears to me to be desirable that in studying the phenomena of electric discharge in gases and especially in vapors of complex substances, the horrible pitfalls should be taken into account with which the field of work is studded; unless every precaution to secure purity—precautions such as Baker and Dewar have taught us to use—be taken at every step, the conclusions based on all such observations must be open to grave doubt.

ROTATING LIQUIDS USED AS MIRRORS.

PROF. WOOD'S EXPERIMENTS.

Various attempts have been made to utilize, for optical purposes, the paraboloid surface which a liquid, such as mercury, assumes when rotating with uniform velocity. The experiments, hitherto, have not been very thorough or conclusive, for two reasons. First, because the requisite uniformity of rotation could not be attained, owing to the imperfection of the mechanism employed; and, secondly, because there was little inducement to pursue the research, when the necessity for maintaining the liquid in a horizontal position limited the use of the telescope to the zenith of the place of observation. The employment of telescopes in a vertical position, in connection with auxiliary plane mirrors to reflect the light from any part of the sky to the optical surface, has removed one objection, and improvement in mechanical devices gives reason to anticipate better results than formerly. At the same time, the hope of obtaining mirrors of very short focal length, which would assist investigations in certain directions, should furnish an additional spur for prosecuting these experiments. But Prof. R. W. Wood, who has recently taken up this inquiry, does not seem to have been influenced by any of these motives. To him the attempt offered a mechanical puzzle of great delicacy, and promised an interesting diversion. The problem, as it presented itself to him originally, was to devise a method for rotating a fluid without, at the same time, communicating jars to it. His success tempted him to continue the experiments, and his results, if they do not prove to be of any practical importance, are of very great interest, as demonstrating the perfection to which engineering skill has attained, and as suggesting a revolution in the manner of working reflecting mirrors.

His plan was to communicate motion to a circular basin, containing mercury, by means of a rotating magnetic field. A shallow iron basin, 7 inches in diameter, mounted or fitted with a short cylindrical pillar which served as a pivot, was arranged to be driven by a revolving ring of small magnets, which pulled a concentric ring of magnets fastened to the basin round with it. The form of the pivot and the method of mounting are of no great consequence at present, for these are still subjects of examination, because, as the trials proceeded, it was found that some of the difficulties in securing stability or regularity arose from the form and the extent of the bearing surfaces and the way in which friction affected the result. The rotor, as Prof. Wood calls the outer ring of magnets, was mounted on a support which was completely insulated from the mercury basin, so that the jars which it received from the motor through the driving-belt were not communicated to the basin. Any hope of testing the adequacy of the contrivance as at first arranged was frustrated by the vibration due to city traffic, and this will be readily understood when it is stated that afterward, when the instrument was removed to the country, and mounted in the steadiest manner ingenuity could suggest, it was still possible to detect the approach of a horse and carriage at a distance of 200 yards, and the footsteps of a person running across the lawn fifty yards from the telescope house caused a perceptible vibration of the image. The pounding of the surf on a beach a quarter of a mile distant was noticeable. These details indicate the degree of uniformity which the rotation must reach if success is to be attained.

Subsequently a 20-inch reflecting surface was substituted for the one of 7 inches, changes in the form of mounting were made, particularly by replacing the inner ring of magnets by fine elastic threads of rubber, to pick up the power of the rotor, and the whole apparatus was placed at the bottom of a well, to which access was possible from a second well parallel to the first, with a tunnel connecting the two. These precautions are necessary to secure the best results, but the interest centers rather in the causes of disturbance that give rise to ripples on the mercury surface, and the optical effects produced. Leaving out of consideration those irregularities which have a purely mechanical origin and are traceable to imperfections of workmanship, there were found to be two sources of error which will demand very careful attention from anyone who attempts to repeat or to improve upon these experiments. One is due to a kind of tidal wave set up by inaccurate leveling. When the basin is not quite level, the depth of mercury is greater on the lower side. The point of maximum depth will be carried round to the high side by the rotation of the dish, and the mercury will seek to establish its level again. This continual readjustment of level produces a spiral eddy, whose optical effect is shown on a star image by a very distinct coma. Nice adjustment of foot-screws, bringing the image into what may be called the permanent optical axis, removes this defect. The displacement of the image, and the reappearance of the coma by a slight motion of the leveling-screws, are precisely similar to what is seen in the case of a solid mirror; a result that would hardly have been anticipated, the speed of rotation being only about one turn in 3.5 seconds.

Another kind of ripple, of a much more subtle character, arose from periodic variations in the velocity of rotation. This class of ripple was found to start from the rim, and not from the center of the mercury, and was in some cases due to roughness on the inner surface of the dish, or to the presence of grains of sand. But a deeper-seated source of trouble was occasioned by a slip between the mercury and the iron rim of the basin. The rotor and basin did not turn at precisely the same velocity, owing to slight irregularities in the friction in different parts of the revolution. At the position of maximum friction, the dish lagged behind the rotor; when this point was passed, there was a slight acceleration, and the basin got ahead of the rotor. The actual amount of separation in one rotation was about a centimeter. The optical effect of this irregularity was very curious. The small change in velocity could not be communicated to the liquid mercury, for a very considerable time is required for the whole mass of the mercury to accommodate itself to the movement. This is clearly shown at starting the rotation. The mercury takes up the velocity first at the rim, and the motion is seen to travel toward the center, some two minutes being required for the whole mass to acquire a constant angular velocity. But what does happen is, that at each reduction of speed there is the least possible drop of the liquid at the rim, and similarly a rise at the center, causing a change of curvature—an almost instantaneous change—sufficient to produce a periodic oscillation in the position of the focus. On looking without an eyepiece at the star images formed by this rotating surface, "they were seen to be rising and falling rhythmically, dancing up and down like will-o'-the-wisps." With an eyepiece, it was at once seen that the focus changed periodically through a range of, perhaps, an inch and a half. "There were moments when the images were quite sharp in the eyepiece, but even then they were not quite stationary, moving about in a sort of Lissajou figure, perhaps a millimeter in diameter."

The change of focus is well shown by photographs of the trail of γ Cygni. The developed image is a line dotted with bright points at regular intervals. When the focus coincided with the film a bright dot resulted at other times the image was spread out, causing a faint line. The points, or dots, are small, however, not much larger than they should be by theory; and when we consider the difficulties that have been overcome to get this effect, and especially the ingenuity exhibited in the careful analysis of the causes that have produced the deformations, we feel that Prof. Wood is likely to achieve ultimate success. In any case, if the ripple cannot be prevented forming by the adoption of particular mechanical devices, the effect can be rendered imperceptible by damping. A thin layer of water which will assume the same curvature as the mercury is very effective in giving greater stability to the image, but glycerine is still more efficacious. When jarring is so pronounced as to be unpleasant, a coating of glycerine, to the depth of about 4 millimeters, will secure a very satisfactory image.

The focal length of the mirror, when the photograph was obtained, was about 15 feet, or nine times the aperture; but the great range of focus possible with a rotating mirror is a feature of great importance, and one that suggests a possible sphere of usefulness in the future. Prof. Wood has used such velocities of rotation that the focal length was reduced to less than twice the aperture, and with small mirrors under high velocities, giving rise to deep paraboloids, the focal length was still further reduced, attaining, finally, to one-fourth of the aperture. Where concentration of energy is desirable, as in oolometric observations of the heat of stars, such an instrument is not without promise. On the other hand, if long focal length be required, this also can be secured.

Whether these experiments will suggest improvements in the casting and figuring of mirrors seems doubtful. It is not impossible that some substance may be found which would be capable of being rotated in a fused state, allowed to solidify while rotating at a constant velocity, and in that way securing a permanent figure. Prof. Wood tells us that he made a fairly good mirror of gelatine, and that he is now in search of a more stable medium, and he will welcome suggestions about fusible media that will solidify with an optical surface. Also by pouring a hot viscous liquid over a rotating mercury surface and allowing the material to cool, he has obtained very good convex paraboloids. Resin has given fairly satisfactory casts, which can be electrotyped and silvered. Provided the electrotypes do not warp, it seems possible to construct, in this way, large mirrors at comparatively small expense.

We congratulate Prof. Wood, who has described his work in an interesting paper contributed to the Astrophysical Journal for March last, on having conducted to a successful issue an inquiry that demanded much ingenuity. Optical tests are of the utmost delicacy, and one result of Prof. Wood's paper is to show what may be expected from accurate workmanship, and to reveal unsuspected sources of weakness in mechanical design, which would not be detected without such refined methods. Although the original problem was to make a fluid rotate without jarring or rippling the surface, it is possible we shall learn rather the best way to reduce friction—or irregularities of friction—between two bearing surfaces, than be taught a new device in the figuring of mirrors.—Engineering.

MODERN PETROLEUM LIGHTING.

The petroleum lamp is often wrongly abused, and some of its defects can very easily be corrected. It is necessary to take account of the quality and the character of the oil employed. A lamp made for American oil works poorly with Russian oil. For this reason, the Rumanian government last year passed a law defining the conditions to be satisfied by illuminating oil. The quantity of light given by a lamp depends largely upon the quantity of oil in the reservoir. An increase of 20 per cent in candle-power was obtained by increasing the quantity of oil from one pint to one pint and a half. This is due to the fact that the force of capillarity is increased when the level of the liquid is raised. The nature of the wick is important. Incombustible wicks of asbestos have been recommended. The recently invented Monasch wick is formed chiefly of carborundum. The reflector which is used in small household lamps is of little utility.

Recently, incandescent burners have been introduced, the oil being vaporized and mixed with air in definite proportion. In the Kitson system the vapor, compressed to three atmospheres, flows through a small copper tube to a small heated chamber, from which it flows through a pinhole into a Bunsen burner. This system is extensively employed in the illumination of lighthouses and wherever a very intense illumination at a single point is required. The Empire lamp, sold in England and the United States, is a portable apparatus constructed on this system, but improved in that the heating chamber is placed a little to one side of the burner instead of directly above it.

The Blanchard system uses kerosene oil and an inverted incandescent mantle. The peculiarity of this system is the addition of a second vaporizing chamber, in which the heavier parts of the oil collect and are vaporized by the heat of the mantle. By the employment of the inverted burner it is possible to obtain a power of from 75 to 200 candles from a small lamp. An ingenious device indicates the level of the liquid in the vaporizer, which is entirely closed and under the pressure necessary to good lighting. This device consists of a float carrying a magnet, the motions of which are followed by a needle outside the vaporizing chamber. The lamp burns twenty hours without attention. Vaporized hydrocarbons are employed in a different manner in the Petrolite lamp, in which the air is drawn through a spongy mass saturated with oil, the necessary draft being produced by a tall chimney. This lamp is remarkably safe, for it is immediately extinguished if overturned or the chimney broken.

The various methods of carbureting air with petroleum vapors are of great interest in connection with illuminating systems. The usual apparatus includes a small hot-air motor driven by the waste heat of the gas produced, a blower, a carbureter, and a gasometer. In some cases clockwork driven by a weight or hydraulic power is used, but an automatic apparatus is preferable. The value of a system depends chiefly upon the uniformity with which the mixed gases are supplied to the burner. The mixture should contain about 1.5 per cent of petroleum vapor and 98.5 per cent of air.

A PERPETUAL CLOCK.*

THE INGENUITY OF JAMES COX.

BY CHARLES E. BENHAM.

THE quest for perpetual motion has, of course, long ago ceased, as the result of a better acquaintance with the principles involved in Newton's law of the equality of action and reaction; but the fact has almost passed into oblivion that in the eighteenth century there was actually constructed, by an ingenious jeweler named James Cox, who lived in Shoe Lane, London, a clock which was practically a mechanism of perpetual movement, the timepiece being rendered self-winding by a cleverly-contrived attachment consisting of a barometer arranged to actuate a cogwheel in such a manner that whether the mercury rose or fell, the wheel always revolved in the same direction, and kept the weights that supplied the movement of the clock always wound up. Slight as the changes of atmospheric pressure may be at certain times, Cox's difficulty was not by any means their insufficiency, but, on the contrary, their over-sufficiency for his purpose, and the most troublesome difficulty he had to solve was the prevention of the fracture of the chain by overwinding—a mishap which he ingeniously got over by a device which caused the cogwheel to throw itself out of gêar when the weights were nearly full wound up, and only resume its function after they had descended again a certain distance. The clock itself had nothing special about it, except that it was appropriately made of a very durable character, and jeweled at every possible bearing, the whole being inclosed in a dust-tight glass case, so that the mechanism was clearly visible. Fig. 1 shows a general view of the instrument, and Fig. 2 gives a more detailed diagram of the barometric winding apparatus. *A a* and *B b* are metal rockers, from the ends of which is suspended by rods the gimbal-mounted frame, *F*, with its attached barometer bulb *H*, the tube of which goes down into the glass cistern of mercury, *K*. The cistern is also suspended from the rockers by rods, and the mode of support is the important part of the invention. The rods supporting the bulb hang from *A* (the extremity of one rocker) and *b* (the opposite extremity of the other), while the cistern hangs from the other opposite extremities—namely, *B* and *a*. It will be seen on reflection that, as the result of this arrangement, if the bulb is drawn down, it must draw up the cistern, and if the cistern is pulled down it will draw up the bulb, for, as either end of a rocker goes down, the other end must rise. The cistern being open at the top, the varying pressure of the air forces more or less mercury into the bulb. If the weight of the bulb is increased in this way, it descends, and if the weight of the cistern is increased, the bulb ascends, being made lighter. The frame, *F*, rises and falls with the bulb, and to the frame is attached the winding-up frame, *M*,

FIG. 1.

shown on a larger scale in Fig. 3. In this frame are teeth pointing downward on one side of the frame and upward on the other. When the frame descends, the downward-pointing teeth engage the wheel *N*, and when it rises, the other teeth act on the same wheel, which in either case is uniformly turned in a clockwise direction. The frame itself moves between four friction wheels which keep it in an upright position. *O* is a catch to insure that by no accident can the wheel move counter-clockwise. On the back of the wheel *N* is a pulley with pin-points to take an endless chain. This chain, returning to Fig. 2, passes over the pulleys *U U* and under the two lower ones, *S* and *s*, then over the pulleys *V V*, and over the axis of the great wheel *R*, by which the movement of the clock is effected, by the medium of the weight *T*. The corresponding weight, *t*, is merely a light counterpoise, consisting of an empty brass box, *T* being a similar box filled with lead. Thus *T* acts with half its force

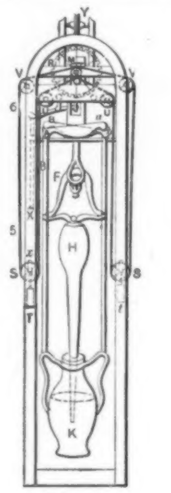


FIG. 2.

of gravity on the part of the chain marked 5 and 6, and with half on the part marked 7 and 8. The train of movement is such that the great wheel *R* would keep the clock going a whole year before the weight would descend quite to the bottom of the machine; but, apart from this, the alternating pressures of the atmosphere operating through the toothed frame, keep the weight from ever getting near the bottom. The weight of the quicksilver was 150 pounds. To avert overwinding, Mr. Cox made the wind-up wheel to turn loose on the arbor whenever a click was discharged from its ratchet-wheel. The discharge of the click was effected whenever the top, *x*, of the pulley frame, *S*, reached the rod *X*. To counterbalance the weight of the wind-up frame *M*, a chain with weight passed over the pulley *Y*, at the top of the machine. As the weight *T* has four feet of descent from top to bottom, irregularity would have been produced by the variation in length of so much chain, the clock having a balance and not a long pendulum. To obviate this, *T* was made to wind up a smaller weight every twelve hours by means of a remontoir, and it was this smaller weight, acting upon the timepiece, that kept it in motion.

The inventor, whose many other ingenious contrivances were a theme of continual interest and wonder in his day, had an engraving made from which the above illustrations are copied. It was inscribed "To the King's Most Excellent Majesty," and accompanying the diagrams was a letterpress description written by the celebrated James Ferguson. Cox's Museum in London was a repository of treasures of mechanical genius and jewelers' skill, such as can rarely have been surpassed. In 1765, according to the Annual Register, he made a cap or crown containing 4,000 jewels and workmanship of the most elaborate order to suit the fancy of an East Indian nabob, and ten years later, at a great rout at the Mansion House, he was engaged to add to the charms of the banquet by a number of automatic musical instruments, which caused the greatest delight to the guests, who numbered over a thousand.

In 1773 Cox obtained the royal assent to an Act of Parliament enabling him to dispose of his museum, but it was not until the next year that the clock was introduced. Its inventor seems to have been very chary of giving to the public a full explanation of the "philosophical and mechanical principles" on which he vaguely announced that it was based, and the clock remained a complete mystery until James Ferguson, after a complete inspection, publicly divulged the secret, at the same time adding his testimony to the soundness of the inventor's device in the following memorandum:

"I have examined the above-described clock, which is kept constantly going by the rising and falling of quicksilver in a most extraordinary barometer, and there is no danger of its ever failing to go, for there is always such a quantity of moving power accumulated as would keep the clock going for a year even if the barometer should be taken quite away from it; and, indeed, on examining the whole contrivance and construction, I must, with truth, say that it is the most ingenious piece of mechanism I ever saw in my life.

"James Ferguson.

"Bell-court, Fleet-street, Jan. 28th, 1774."

Almost the strangest part of the whole story of Cox's clock is the dramatic sequel of its fate, which was as regrettable as it was astonishing, and as comical as it was pathetic. The circumstances are incidentally brought to light in a work entitled "Travels in China," published in 1804 by John Barrow, who was private secretary to Earl Macartney. From this volume it appears that in the list of presents carried "by the late Dutch Ambassador" were two grand pieces of mechanism from the Cox Museum, one of which appears to have been the perpetual clock. In the course of the long journey of the Dutch Embassy from Canton to Pekin, both the machines had suffered some slight damage, and an endeavor was made at Pekin to have them repaired; but on leaving the capital it was discovered that the wily Chinese Prime Minister, Ho-tchangtong, had substituted two other clocks of very inferior workmanship, and had reserved the two masterpieces for himself—it was believed with the idea of presenting them at some future time as gifts of his own to the Emperor of China, so as to gain imperial favor. Whether the perpetual clock is still ticking quietly on the wall of some chamber in the Imperial Palace at Pekin, or whether it has come home with other loot, and now reposes in some storehouse of second-hand goods in the east end of London, it is impossible to say. It is at any rate satisfactory that so complete a record of the mechanism remains, so that if anyone would spare the money and the trouble it could be reconstructed almost exactly as it stood in Cox's Museum more than one hundred and thirty years ago.

The decomposition of carbonic acid by ultra-violet rays is discussed by M. H. Herchefinkel in a paper presented to the Académie des Sciences. H. Thiele had already found that such rays facilitate the combination of oxide of carbon and oxygen at the ordinary temperature, but he was not able to note any action on a mixture of carbonic acid gas and damp hydrogen. Herchefinkel uses a quartz mercury vapor lamp as a source of ultra-violet rays, and he finds that there is a decomposition of carbonic acid gas into carbon monoxide and oxygen by the action of the rays. Analysis of the gas was made by one of the most sensitive methods. The

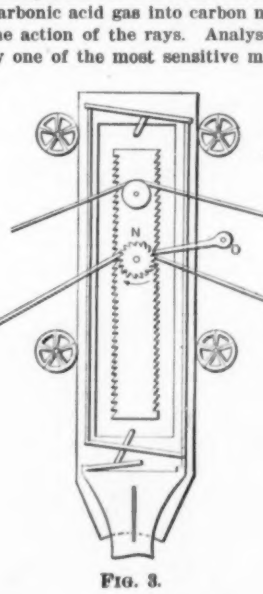


FIG. 3.

bulb containing the gases contained a small amount of mercury in order to absorb the oxygen which was formed. An exposure of about 80 hours was made to the rays, and another bulb was kept separately as a check on the experiment. No trace of carbon monoxide was found in the unexposed bulb. The mercury which was exposed to the rays shows a yellow surface layer of oxide. Before making these experiments the author tried the action of radium emanation on carbonic anhydride, and found that there was produced a measurable quantity of carbon monoxide. These latter results confirm the tests made by Messrs. Ramsay and Cameron on the same subject.

* English Mechanic and World of Science.

THE PROBLEM OF TELEPHOTOGRAPHY.

A NEW SYSTEM OF ELECTRICAL TRANSMISSION OF PICTURES.

BY DR. ROBERT SCHOENHOEFER.

THIS new system of electrical telephotography is based upon the division of a picture into an indefinite number of small areas, each of which is more or less filled with black, so that the areas taken together produce the impression of a picture similar to that obtained by the reproduction of photographs in the methods of "process" printing. The picture to be transmitted is projected in greatly enlarged form upon a screen made up of small selenium cells. Each cell can be electrically connected to the corresponding electromagnetic element of the receiving screen at the distant station, and the picture thus produced is photographed on a reduced scale (Fig. 1). The apparatus of the sending station consists of the projecting lantern (*A*), the selenium screen (W_s), the synchronizing apparatus (S_1), and the battery (*E*). The receiving station contains the synchronizing apparatus (S_2); the electromagnetic receiving screen (W_e), the lamp and reflector (*B*), and the photographic camera (*P*).

The function of the projecting apparatus is to throw on the selenium screen an enlarged copy of the picture to be transmitted. It differs in no respect from an ordinary projection apparatus. The picture may be a positive or a negative, on paper, glass or film. Images of solid objects, human beings, landscapes, etc., may also be projected and transmitted.

The selenium screen is made up of small and equal selenium cells of square or hexagonal form, inclosed in a frame of hard rubber or other non-conducting material (Fig. 2). To each cell are connected two wires, one of which leads to an earth wire and the other to the synchronizing apparatus.

The latter is a disk or cylinder which carries mutually insulated conducting pieces in number equal to the selenium cells. If a cylinder is employed these pieces are arranged in a helix.

Each piece is connected by a wire with one of the selenium cells. Over these pieces moves a sliding contact piece connected with the battery. The slider moves in a helix around a cylindrical apparatus, and in a circle around a disk. The battery is of the form commonly used in telegraphy, but any other suitable source of current may be employed. Its poles are connected by the line wire with the sliding contacts of the synchronizers at the two stations. The synchronizer of the receiving station is precisely similar to that of the sending station. Each of its fixed conducting pieces is connected with one element of the electromagnetic screen.

The arrangement of these elements is the same as that of the selenium elements, but for constructive reasons the dimensions are greater. Here, too, the frame is made of non-conducting material. While the selenium screen may be placed in any position, provided that it is perpendicular to the axis of the projector, the electromagnetic screen must be horizontal, as gravity is employed in its operation. In each element of this screen (Fig. 3) is a small electromagnet,

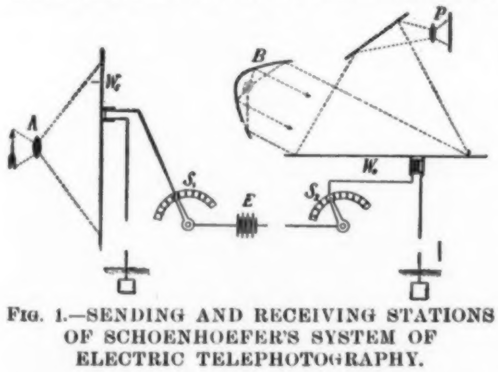


FIG. 1.—SENDING AND RECEIVING STATIONS OF SCHOENHOEFER'S SYSTEM OF ELECTRIC TELEPHOTOGRAPHY.

the iron core of which is a longitudinally perforated prism with rounded edges. Through the perforation a vertical rod moves freely, bearing at its upper end a white plate and at its lower end a flat piece of iron. One end of the wire of the electromagnet is connected to earth, the other to one of the fixed contact pieces of the synchronizer. The lamp and reflector are so arranged that a bundle of parallel rays is thrown very obliquely upon the upper surface of the electromagnetic screen. A source of light in the focus of a parabolic mirror may be used, or direct sunlight, diffused daylight, or rays from a distant source may be employed.

The photographic camera is of the usual form. For convenience of operation the image is reflected into it by a plane mirror (Fig. 1). The operation of transmitting the picture is conducted as follows:

Each selenium cell at the sending station receives from the fragment of the picture thrown upon it a definite amount of illumination, which remains constant during the entire transmission and develops in the selenium a definite resistance to the electric current.

Through the operation of the two synchronizing devices connection is established successively between each selenium cell and the corresponding electromagnetic element at the receiving station. A brightly-illuminated selenium cell will have a small electrical

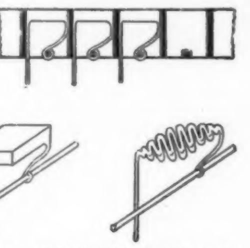


FIG. 2.—SELENIUM CELLS.

resistance, and the electrical impulse sent to the corresponding electromagnetic element during the moment in which the two elements are connected by the line wire will be sufficiently powerful to raise the core of the electromagnet to its maximum height, and bring the white plate into the position of maximum illumination. After the cessation of the current the core falls and carries the plate to the position of darkness. If, on the other hand, the selenium cell is in the dark part of the picture its resistance will be so great that the weak current sent through it to the corresponding electromagnetic element will not be sufficient to overcome gravitation and raise the core, so that the plate will remain in the position of darkness. In intermediate degrees of illumination the current will be of intermediate strength and the white plate will be raised to a position of partial illumination, the intensity of which will depend upon its elevation owing to the oblique incidence of the rays and the shading of the plate by the partition walls of the frame (Fig. 3). Evidently the return of the plate to the dark position could be effected by springs, with which arrangement the screen need not be horizontal, but the mechanism of the electromagnetic elements would be less simple and precise. The results of these operations is the production on the electromagnetic screen of a mosaic picture in which the distribution of light and shade corresponds to that of the original picture projected on the selenium screen. This mosaic is then photographed, so that a negative picture of an actual object or of a positive picture is obtained at the receiving station, while a negative picture is transmitted as a positive. In regard to the practicability of this process, the problem of synchronizing has already been solved in other forms of apparatus. The construction of the selenium and electromagnetic screens offers no special difficulty except that of making all the elements of each precisely alike. This result could be obtained as follows:

At first a selenium cell and electromagnetic element are constructed so that they will work properly together within prescribed limits of illumination and current; then the other elements are patterned after these and carefully tested and corrected, by appropriate means.

The desired current strength can always be obtained. It will be more difficult to bring the illumination within the prescribed limits, as pictures of various tones will be offered for transmission, but by modifying the current by the introduction of resistance and the illumination by changing the angle of incidence, sharp and well-toned pictures can always be obtained.

In order to get an idea of the dimensions of the elements let us assume that a picture measuring six by eight centimeters (2 1/3 by 3 1/7 inches) is to be transmitted. Sufficiently fine detail can be obtained with elementary areas ½ millimeter (1/50 inch) square. This gives, for the picture in question, 30,000 areas and the same number of selenium and electromagnetic elements. If we make the electromagnetic elements 10 millimeters (2/5 inch) square and the selenium cells 5 millimeters (1/5 inch) square the electromagnetic screen will measure 1½ by 2 meters (60 by 79 inches), and the selenium screen ¾ by 1 meter (30 by 40 inches). If we have to transmit larger pictures with the same apparatus the pictures will have to be sent in parts. In the transmission of images of landscapes and persons, this subdivision can be effected by partly covering the projected images. In regard to the time of transmission, it should be observed that during this whole time the illumination of the selenium cell remains constant and that each electromagnetic element acts only once, for an instant. Hence, with full regard to the inertia of the selenium cells and of the magnetic and mechanical parts, the time of transmission of the whole picture may be estimated as one or two seconds, so that from 1,000 to 2,000 such pictures could easily be sent in one hour. This suggests the idea of operating the apparatus continuously. This offers no great technical difficulty, as the pictures at the sending station and the film at the receiving station could be moved rapidly but intermittently by kinetographic apparatus.

The new process offers several important advantages. The rapidity of transmission is much greater than that of other methods and sufficient for all practical needs. Furthermore, images of pictures, landscapes, persons, and all other motionless objects of any size can be transmitted, so that the preliminary production of a relief or other photograph of prescribed dimensions is avoided. The reversal of the picture from positive to negative in transmission may also be desirable for some purposes, and a very important advantage is the mosaic character of the received picture, which enables it to be directly transferred to a printing plate. Hence this process should be very valuable to illustrated journals, while its speed would make it extremely useful to the police in tracking criminals. Finally, it may be of use in war in transmitting pictures of the enemy taken from an elevated point of observation. The process, however, has one serious disadvantage; namely, the great cost of installation, although this is largely compensated by the very great capacity of the apparatus.

In regard to the possibility of transmitting moving pictures, a discrimination must be made between indirect and direct transmission. The problem of indirect transmission of moving pictures is already solved. The operation would be conducted as follows:

The moving scene would be photographed by a moving-picture camera, and the strip of negative film thus obtained would be transmitted to the distant station by the continuous operation of the apparatus as outlined above, thus producing at the receiving station a strip of positive film, which could be immediately developed and projected.

Assuming the action to occupy ten minutes and require 15 pictures per second about five hours would be required for the electrical transmission. Here, therefore, we have the seductive prospect of seeing an important event reproduced in moving pictures in every city of the Continent on the very day of its occurrence.

In regard to the direct transmission of pictures,

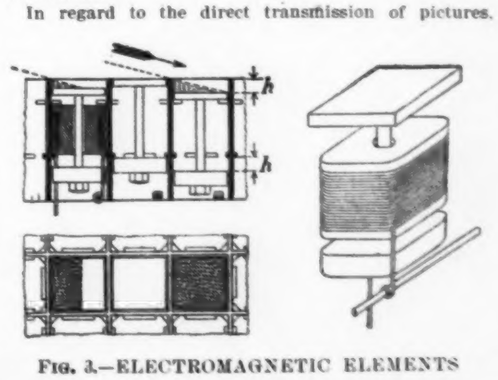


FIG. 3.—ELECTROMAGNETIC ELEMENTS

that is to say, electrical vision at a distance by this method, only conjectures can yet be expressed. It would be necessary to transmit at least fifteen pictures per second. Then, if a ground glass screen were substituted for the photographic plate the observer would see a moving picture of the events transpiring at the other end of the line. The same result would be obtained by directly viewing the electromagnetic screen from a proper distance.

The question is, therefore, whether it is possible to construct selenium and electromagnetic elements which can transmit and receive fifteen impulses per second. For the selenium cell the problem appears to have been solved by the ingenious compensator devised by Dr. Korn. The sensitiveness of the electromagnetic elements can be greatly increased by reducing to a

minimum the play of the cores and disks, and at the same time diminishing the angle of incidence of the illumination. It might be questioned whether the synchronizing mechanism would work satisfactorily with 15 x 30,000 electrical impulses per second, but this difficulty may possibly be evaded by dispensing with exact synchronism and merely taking care that the periods of rotation of the two sliding contacts shall be exactly the same. The result would generally be a distorted picture, the distortion being produced by a difference of phase between the selenium and the electromagnetic elements, but this difference of phase could be corrected very simply by turning the disk or cylinder at the receiving station to a greater or less extent, which could never exceed one revolution. In the first place a well-known picture consisting of simple lines would be transmitted and the receiving cylinder turned until the distortion disappeared. The moving pictures could then be transmitted.—Translated for the Scientific American Supplement from Rundschau für Technik und Wirtschaft (Prague).

RECENT ELECTRICAL PROGRESS.*

THE ARTIFICIAL LIGHTING FIELD.

BY ALBERT F. GANZ, M.E., PROFESSOR OF ELECTRICAL ENGINEERING, STEVENS INSTITUTE OF TECHNOLOGY.

Concluded from Supplement No. 1760, page 200.

Vapor lamps are not directly comparable with other sources of light in an ordinary photometer due to the large linear dimensions of these lamps, and, in the case of mercury vapor lamps, also due to the wide difference in color. These lamps should be compared with some form of luminometer by which the illumination produced is measured. From this a figure equivalent to spherical candle-power can be derived. For the Moore tube a specific consumption of about 1.5 watt per equivalent candle-power is claimed. Sharp and Millar report 2.49 watts per equivalent spherical candle-power, for a Moore tube installed in 1907, in Assembly Room No. 7 of the United Engineering Buildings.

The mercury vapor lamp depends upon the production of an arc between a negative electrode of mercury and a positive electrode of mercury, carbon, iron, or other suitable conductor within a transparent tube, exhausted so as to contain only vapor of mercury. The mercury vapor lamp was developed by Dr. Peter Cooper Hewitt, in 1901, and was shortly afterward placed upon the market by the Cooper-Hewitt Electric Company, one of the Westinghouse interests. This lamp consists of a glass tube about one inch in diameter, and, for 110 volts, about 4 feet in length. The mercury vapor lamp is inherently a direct-current lamp, but has recently also been manufactured for alternating-current circuits. In the direct-current lamp there is a positive electrode, usually of carbon or iron, at the upper end of the tube, and a negative electrode of mercury at the lower end; this end of the tube is provided with a condensing chamber, in which the vaporized mercury issuing from the negative mercury electrode is condensed and returned, thus constantly reconstructing this electrode. The positive electrode undergoes no change. To force an initial current through the mercury vapor of a lamp would require several thousand volts; after a current has once started, however, the voltage required to maintain the flow of current is comparatively low. The high resistance to starting is found to exist almost entirely at the surface of the negative electrode. The lamp is usually started by tilting the tube until the mercury bridges across the gap between the electrodes, thus striking an arc, and this may be accomplished by an automatic device. A special starting device, employing the high voltage discharge from an inductance coil, has also been developed. The mercury vapor lamp requires a steadying resistance or ballast in order to operate on constant potential like an arc lamp. A peculiar feature of this lamp is that if the current is interrupted for even the briefest possible moment the arc is immediately extinguished and cannot be re-established without first breaking down the resistance at the surface of the negative electrode. Thus the lamp can be made to operate only on alternating current by embodying the principle of the mercury vapor rectifier. Instead of the single positive electrode there are provided two positive electrodes, which are connected to the ends of the winding of a suitable transformer. The negative mercury electrode is connected through an inductance and a ballast resistance to the middle point of the transformer winding. The arc is started by means of an auxiliary starting electrode, as in the case of the rectifier. During the successive half waves, current flows alternately from each of the positive electrodes through the vapor in the tube to the negative electrode. Thus the successive half waves travel down the tube in the same direction, and if sufficient inductance is present there is no perceptible flicker in the light. The most important characteristic feature of the mercury vapor lamp is its color, which is a bluish-green, corresponding to the spectrum of mercury. The light is practically void of red rays so that red articles appear black, and colors are generally distorted, which makes the lamp unsuitable for use where colors are to be matched or compared. These lamps are, however, successfully used in machine shops, pressrooms and similar places where details must be accurately seen, but where color distortion is no disadvantage. Owing to its very strong actinic rays, the lamp also has considerable value for photographic purposes. Dr. Bell gives a specific consumption of 0.6 to 0.8 watt per equivalent candle-power for these lamps.

Cooper-Hewitt mercury vapor lamps have been constructed with tubes bent into a circular form, so as to fit in a diffusing globe. In some cases incandescent lamps have been added in the fixture for the purpose of supplying the red rays missing in the mercury vapor light. A prominent example of commercial lighting by units combining a Cooper-Hewitt mercury vapor lamp with a tungsten incandescent lamp, is found in the editorial offices of the New York World, where 36 of such light units have been in use since May 1, 1908. Each light unit or combination lamp, as it may be called, consists of a Cooper-Hewitt mercury vapor tube bent into circular form of about 10 inches diameter, with a tungsten lamp in the center. The vapor tube and tungsten lamp are attached to an ornamental metal fixture provided with a white, corrugated reflector and surrounded by a 16-inch holophane hemispherical globe. The combination lamp is designed to operate on the 120-volt Edison circuit, and to take a current of 2 amperes, thereby consuming 240 watts. The vapor tube and tungsten lamps are connected in series, the vapor tube taking about 52 volts and the tungsten lamp about 58 volts, the remaining 10 volts being taken up by steadying inductance. An automatic device consisting of an inductance coil with a quick mercury break in vacuum, called a shifter, is placed in the fixture for starting the lamp. Tests of the illumination produced by this installation, made by means of a luminometer, and of the power consumed, are described by Mr. Albert J. Marshall, in the April, 1909, issue of the "Transactions of the Illuminating Engineering Society." Mr. Marshall states that the candle-power of the tungsten lamp is about 80, and of the Cooper-Hewitt vapor lamp about 200. With a power consumption of 240 watts, this gives an equivalent specific power consumption of 0.86 watt per equivalent candle.

In attempting to improve the color of the mercury vapor lamp there have been developed quite recently in Europe new types, which have been referred to as high pressure mercury vapor lamps. The two most prominent examples of these types are the Bastian lamp, brought out in England, and the quartz tube mercury vapor lamp, brought out first in Germany by Richard Kuch. In the Bastian lamp the arc is produced in a tube of refractory glass about an eighth of an inch in diameter and 9 to 10 inches long, for lamps which are designed to operate at about 110 volts. The intensity of the arc, combined with the small size of the tube, causes the pressure of the mercury vapor to rise to much higher values than with the Cooper-Hewitt form of lamp. This greatly increases the temperature of the mercury vapor, and consequently greatly improves the color of the light, the yellow rays becoming very pronounced. In the lamps due to Kuch there is used a tube of fused quartz in which the arc can be run at a very high temperature. This lamp has a tube about 3 inches long for a pressure of 110 volts. The quartz tube mercury vapor lamp has already become commercial in Germany. Its specific power consumption is quoted as 0.2 watt per mean spherical candle. None of these high-pressure mercury vapor lamps have so far been used in America.

Development of Machinery and of Systems of Distribution.—The first electric lighting of commercial importance was accomplished by means of direct-current carbon open arc lamps, connected in series and supplied from constant-current dynamo machines, and by the year 1880 a number of such systems had already been developed and introduced for street lighting. During the following five years street lighting by direct-current series arc lamps spread very rapidly both in Europe and in America. The Brush arc dynamo machine developed during this early period has survived to the present day, and is still largely used for series direct-current arc lighting systems. Efforts to introduce series arc lamps for indoor lighting were also made as early as 1878 by Weston, Brush, and by others, but did not meet with favor largely because the arc lamp was too large a light unit and because the color was too different from the accustomed gas flame; the introduction of the incandescent lamp soon afterward discouraged attempts to use arc lamps for general indoor lighting at this time.

The introduction of the commercially successful incandescent lamp in about 1880 brought about the development of constant-potential dynamo machines and systems of distribution. Direct current at from 100 to 125 volts pressure was generally used, and the 16-candle-power lamp was adopted as the light unit, and in fact constant potential dynamo machines were frequently rated by the number of 16-candle-power lamps which they could supply. The Edison and Weston incandescent lamp systems were soon generally used for isolated plants. Edison immediately set to work to develop a complete system of electric lighting which would parallel the gas lighting systems in use. His scheme involved a central station, a system of underground conductors and house wiring supplied from these underground conductors. In the summer of 1880, Mr. Edison installed such a system at Menlo Park, lighting houses and streets with 425 16-candle-power lamps, the out-of-door lamps being mounted on poles. In 1881 the Edison Illuminating Company of New York was organized, which company immediately started to erect its first central station, namely, that in Pearl Street near Fulton Street. This station was started in 1882, and supplied during the first month 85 houses wired for 2,323 16-candle-power incandescent lamps. From this pioneer installation the present system of the New York Edison Company, which is the largest electric lighting company in the world, has developed. This pioneer installation was operated on a two-wire system; the high cost of copper conductors suggested the use of the three-wire system, which was quickly adopted. Soon after the New York company was started Edison illuminating companies in many of the large cities of this country and of Europe were likewise started, these companies all being licensed under the parent company known as the Edison Electric Light Company.

About 1885 the alternating current transformer was introduced. This made it possible to generate and distribute alternating current of high voltage, and by means of these transformers located on poles or on customers' premises to reduce this high voltage to the voltage required by incandescent lamps connected in multiple. Systems were quickly developed consisting of alternating current generators producing generally 1,100 volts at a frequency of 133 cycles per second, which current was distributed to the transformers whereby the voltage was reduced to 55 or 110 volts for supplying incandescent lamps in multiple. The alternating-current transformer system of distribution was pushed most actively by the Westinghouse Company, and this system immediately found extensive introduction in smaller cities and suburbs where the direct-current system could not be economically operated because of the high cost of the copper required. With the introduction of the alternating-current system a heated rivalry started between the advocates of the direct-current system and the advocates of the alternating-current system. However, soon each system found its own proper field of application, the low-tension, direct-current system for isolated plants and for congested areas in large cities, and the alternating-current system for small towns and for outlying districts, and the two systems have retained these separate fields to the present day.

The incandescent lamp was primarily introduced to be used in multiple on constant-potential circuits for indoor lighting, and this has remained its greatest

* Reprinted from the American Gas Light Journal.

field of application. From the early days to the present, incandescent lamps have, however, been used in series on constant-current circuits for street lighting where small light units were desirable, as for streets of villages and suburban towns, shaded parks, etc. Constant current for series incandescent lamps was originally obtained from constant-potential dynamo machines by the use of some hand-regulating device arranged on the station switchboard. Since constant-current transformers were introduced, in about 1902, these series incandescent systems have been most generally supplied from such transformers.

From the first installation up to about 1895, the Edison stations were equipped with direct-current dynamos driven by steam engines. From the 125-horse-power "Jumbo" dynamo, of 1881, the direct-current dynamo machine was developed into the multipolar form in sizes up to about 2,500 horse-power. About 1895 polyphase alternating currents came into use, and the rotary converter as a means of changing polyphase alternating current into direct current had also become a practical machine. This development made it possible to generate electric power as high voltage alternating current, transmit this for considerable distances and then convert into direct current. Since the end of the 90's, Edison companies in large cities have quite generally substituted for the scattered direct-current steam-generating stations, rotary converter substations, receiving their power from one main generating station in the form of 3-phase, 25-cycle, 6,600-volt, or 11,000-volt alternating current.

Alternating-current series arc lamps are most generally supplied from constant-current transformers. Direct-current series arc lamps are still largely supplied from constant-current dynamo machines, principally of the Brush type. About six years ago the mercury arc rectifier was developed by Dr. Peter Cooper Hewitt, by which it was made possible to change alternating current to direct current in a simple and efficient manner without moving machinery. This mercury arc rectifier, combined with the constant-current transformer, makes it possible to obtain a constant direct current for operating direct-current arc lamps in series, the power being supplied to the constant-current transformer from constant-potential alternating-current generators, and generally at very high voltage. Constant direct-current systems employing this arrangement of constant-current transformer and mercury arc rectifier have come very largely into use during the last few years, and are taking the place of constant-current dynamo machines.

Dynamo-electric machines have been developed from the Edison 125-horse-power "Jumbo" dynamo, of 1881, which was then considered "gigantic," to alternating-current generators having normal ratings of 5,000, 10,000, and 14,000 kilowatts, with an overload capacity at least 50 per cent greater than normal rating. These generators produce generally 3-phase, 11,000-volt, alternating current; the usual frequency is 25 cycles per second, where the alternating current is to be used to drive motors or to supply rotary converters for conversion into direct current. Where the alternating current is to be used for lighting arc or incandescent lamps the usual frequency in America is 60 cycles per second.

A good idea of the enormous capacity of a 14,000-kilowatt dynamo machine, the largest so far built, may be gained by considering that this machine is capable of supplying continuously electric current to 560,000 25-watt 20-candle-power tungsten lamps, giving an aggregate light equal to 11,200,000 candles. This practical subdivision of the electric light into over one-half a million units from a single dynamo machine is especially remarkable when it is considered that only forty years ago a number of leading scientists, both in Europe and in America, positively stated that the subdivision of the electric light was a physical impossibility.

MOTOR CAR WHEELS.

THEIR MECHANICAL PROBLEMS.

The great rise which is announced in the price of India-rubber tires—20 per cent—directs attention once more to the various and conflicting problems presented by the wheels of motor cars. We are told, it is true, that the present rise in price is due not to scarcity of raw material, but what is euphemistically termed "a manipulation of the market." The result is the same in so far as the owners of motor cars are concerned. But a temporary rise will not supply that stimulus to invention, or, rather, to the prosecution of research, which a permanent advance in price would give. None the less is it worth considering whether or not further inquiry might leave the world less dependent than it is on India-rubber. We have used the word research advisedly. We have only to look at the Patent Office journals of this and other countries to learn that there is no lack of inventors and inventions. So far as can be learned, however, it appears that next to nothing has been done in the way of testing any of these inventions which are distinctly novel. At all events, the expenditure must be very small, or the facts have been kept very secret. We are not now speaking of substitutes for India rubber, the production of which has been made the subject of much chemical research, but about substitutes for the normal pneumatic tire, the more or less rapid destruction of which represents at once annoyance, danger, and heavy expenditure.

It will save time if we say here at once that we do not propose in what follows to consider what is known as the elastic wheel; that has been very fully dealt with in our columns. Our purpose is to consider briefly why it is that India rubber is regarded as the only material from which a tire can be made. It might, indeed, be supposed that if there were no India rubber trees the modern motor car would have no existence. In what way, then, does India rubber satisfy certain conditions in a fashion and with a thoroughness that leaves it without a rival? The reply usually given to the question is simply that it is elastic; but a very little thought would show that that does not answer the question, because the tire of a motor car is not elastic. We use the word "elastic" in its familiar, not in its precise scientific sense. The air inside it is, and so is the internal tube. But the tire proper—the thing that costs much money and wears out rapidly—is a combination of canvas and India rubber, which is flexible, but not elastic, as everyone who has had to take off and replace even a small motor car tire knows by bitter experience. This outer tire is a casing provided to protect and sustain the elastic inner tube. That, beyond question, must be of India rubber. But its cost is comparatively trifling. If it were not for friction between it and the outer "tube," or tire proper, it would last indefinitely, if spared punctures. The first pneumatic tires were, we believe, fitted to a tricycle. They were really simple India rubber tubes, and had no canvas in their composition. They were very large—about 3 inches in diameter when inflated. A short experience sufficed to demonstrate at once the beauty of the pneumatic system of supporting vehicles, and the utter unfitness of the unprotected elastic tube for use on a road. Then came a multitude of patents; and so the modern tire is apparently a survival of the fittest. It is probable, however, that the initial success attained with India rubber convinced the motor world that nothing but rubber could be used, and so far turned attention away from methods of construction that did not involve its use.

As we have said, the canvas and India rubber outer tube is flexible but practically inelastic. It is not intended to stretch, and will not do so. If it could it would not be able to sustain the pressure inside it of 40 pounds to 80 pounds on the square inch. It possesses the great advantage that it can be molded. Thus the edges can be thickened to take the side grooves provided in the wheel rim to retain it in its place. Furthermore, it possesses a quality most inadequately defined by the word "toughness," that is, the rubber does. When the outer coat of rubber is worn away and leaves the canvas bare, the tire is practically done for. The hemp will not stand the abrading action of the road. This is particularly true of driving tires. In searching for substitutes we find at once that nothing can be combined with canvas to any good purpose but rubber; we reject canvas, and try, let us say, leather. In so far as being adapted to road work, leather answers very well. It is constantly used, indeed, to protect tires, and when studded with steel rivets is said to prevent side-slip. But it would not be possible to fix leather outer tubes on wheels of the normal type. The leather must be converted into a complete tube, and this construction presents almost insurmountable mechanical difficulties with regard to the putting in and getting out of the inner tube. There is, besides, the fact that leather absorbs water, and becomes very limp and helpless. When it dries again it lacks flexibility. It is one thing to put a belt round a rubber tire, and quite another to make a leather tire. All these objections apply to rawhide, which has been proposed. We may at once abandon the theory that nothing will give so much adhesion as India rubber. Canvas or leather will hold much better when roads are greasy; anything will hold when they are dry. Nor is the power of resisting puncture and cutting and abrasions peculiar to rubber; leather and hide are just as good, if not better.

A careful consideration of the whole question leads to the conclusion that the use of rubber and canvas tires is necessary, not because nothing so good can be found to make contact with road surfaces, but because no other material lends itself to a method of construction which has given satisfaction. If the pneumatic system is to be retained, then we must have an elastic, air-tight tube. For this nothing can be suggested as a material but India rubber. This tube does not represent any considerable outlay. The casing in which it is placed must be fairly easily removable from the wheel and from this inner tube. No satisfactory attempt has been made as yet to meet this constructive difficulty. Leather, as we have seen, cannot be molded. "Lips" and thickened edges and such like are impossible. Such materials as gutta-percha and its congeners are totally useless, for well-understood reasons. It may be taken as proved, we think, that no good can be gained by the mere invention of a substitute for India rubber. What is required is a new wheel as a whole—a wheel whose construction will be compatible with the retention of the inner inflated elastic tube. That costs very little—it lasts fairly well. A radical improvement in motor car wheels will be one in the outer tires. In what direction that is to be sought it is not easy to see. It is quite easy to see, however, that nothing can be achieved without the expenditure of much time and money on that kind of research which is represented by constantly making experiments. No doubt success would bring a substantial pecuniary reward. It seems to be certain, however, that for some time to come the owners of motor cars will remain at the mercy of those who bull and bear the rubber markets of the world.—The Engineer.

GLASS-LINED CEMENT TANKS.

Consul Alfred K. Moe draws attention, in the following report from Bordeaux, to the French utilization of the improved cement tanks lined with glass.

Several years ago cement tanks began to take the place of wooden tanks in a number of the larger wine storage houses. One of the reasons for this substitution appears to have been the cheaper cost of material for cement tanks, as the price for timber had been gradually rising, and even at the higher prices was scarce and difficult to secure. Although constant improvement was being effected in the construction and utilization of cement or concrete tanks, the great objection to their use still remained, i. e., that in the storage of wines the acids in the liquid very often decomposed the cement, while the cement walls in turn absorbed the freshness and "bouquet" of the wine. The wooden tanks were more expensive, but their value was greater, as they preserved the wine in a proper condition.

The effort to place acid-proof linings or coating on the walls of cement tanks seems to have proved of slight value in the matter of ameliorating the conditions of absorption. The idea of coating the walls with squares of glass, tightly joined with cement, is said to have solved the difficulty, as a tartar forms on the thin surface of cement and resists all acid attacks.

As constructed in France, glass-lined cement tanks may be used for all kinds of liquids except those containing a large percentage of acids, the latter leading to the decomposition of the cement joints and the loosening of the glass plates. These tanks are particularly useful as storage receptacles for wines, alcohols, brandies, liqueurs, ciders, oils, gasoline, kerosene, turpentine, etc. It is said that tanks so constructed are neither affected by humidity nor by infiltrations, that they resist fire and inundation. Variations of temperature effect a minimum loss by evaporation, the degree being reported at less than 1 per cent. At equivalent temperature wooden tanks lose between 6 and 7 per cent.

These tanks are made in all sizes ranging from 20 to 2,500 hectoliters (528 to 66,042 gallons) or more in capacity. The walls of the larger tank constructions are generally reinforced with iron armature. An installation at Havre consists of eighty-three glass-lined tanks, having a capacity of 11,000 hectoliters (290,587 gallons). At Meurthe et Moselle the plant is two

stories and comprises six vats or tanks with capacity of 1,000 hectoliters (26,417 gallons). Another installation at Seine et Marne is three stories, the third floor being used for the filtration of wine under natural pressure. They also have a capacity of 1,000 hectoliters. The plant at Chalons sur Marne has a capacity of 2,750 hectoliters (72,675 gallons). All of these plants are used for the storage of wines.

These glass-lined tanks, constructed of concrete, are brought to the attention of the wine growers of California especially, and to American producers of cottonseed and other oils, as being valuable for storage purposes under the trying conditions of the climate, their cheapness of construction, their economy of space, and their cleanliness.

A PICTURESQUE ITALIAN RAILWAY.

THE SAN SALVATORE ELECTRIC MOUNTAIN RAILWAY.

BY FRANK C. PERKINS.

THE electrically-operated mountain rope railway at San Salvatore, Italy, is operated by the Societa Bella Ferrovia Lugano-Monte S. Salvatore. From this Italian mountain peak may be seen a fascinating panorama of lakes, rivers, villages, and towns standing out clear with Milan and its exquisite cathedral in the distance. Legend has it that once upon a time Satan, seeing the beauty of this fair spot, hurled a gigantic rock to overwhelm it; but God would not allow the infernal work of destruction, and lifting His hand stopped the threatening mass at a place still called Paradiso: thence the mountain took the name of San Salvatore.

A VIEW OF LUGANO FROM THE SUMMIT OF SAN SALVATORE.
A PICTURESQUE ITALIAN RAILWAY.

One of the accompanying illustrations shows the city of Lugano on the shore of this beautiful Italian lake, while another picture shows the station Lugano-Paradiso of the Ferrovia Funicolare Mont San Salvatore, which lies at the foot of the mountain noted in the background at 1,000 feet above the sea level. The electric power line and electric railway trolley circuit may be noted at the right, the current being conducted on this overhead transmission line to the central station on the electric rope railway located 1,500 feet above the sea level.

The total length of the Paradiso-Salvatore electric rope railway is about 1 mile, the total elevation being 2,200 feet and the horizontal distance 4,600 feet. The upper station, San Salvatore, is 2,500 feet above the sea level, while the summit has an elevation of 2,800 feet.

The electric rope railway track runs from Paradiso to Pazzallo in a straight line for a distance of 2,500 feet, then it curves at a radius of 1,000 feet for a distance of 500 feet and continues for a distance of 328 feet in an opposite curve of 450 feet radius. From this point the line runs on straight with a grade of 17 per cent at first, increasing to 38 per cent at Pazzalo, the grade rising to 60 per cent toward the station at the summit.

One of the principal engineering features on this line is an iron bridge 350 feet long. Besides the Ponte Inferro at Calprino there is another iron bridge 144 feet in length and five stone bridges of novel construction.

It may be stated that the lower part of the line passes over a stretch of stone *débris*, the track construction not being difficult, but the upper section is excavated mostly from the solid dolomite rock or built upon a massive structure of concrete. The gage of this electric rope railway is one meter. The rack rails are solidly fixed in the center of iron sleepers.

There are two cars, each carrying 32 passengers, which pass up and down this electric rope railway by means of a steel cable 5,000 feet in length which travels on iron rollers incased in wood. As one car goes up the other passes down the incline in the usual manner on rope railways, both cars meeting at the middle station so that passengers can be conveniently transferred from one car to the other if desired. The electric power equipment is installed at this station, the equipment consisting of an electric motor operated from the power transmission line and having a capacity of 45 horse-power. A steam engine is also provided, having a capacity of 50 horse-power and held in reserve for an emergency should the electric motor fail for any reason.

The electric motor is coupled by gearing to one of the iron rollers, and acts upon the rope rail, moving it forward or backward as desired. An automatic brake is installed, which operates instantly should the steel cable part, and the speed is regulated by a governor in the power house which also is equipped with an automatic brake. An indicator shows the velocity of the cable, and another dial is installed to show the distance the train covers.

IMPROVEMENTS IN SHIP'S COMPASSES.

THE introduction and increased employment of iron in shipbuilding, and especially the accumulation of great masses of iron in warships, have injuriously affected one important branch of seamanship, namely, navigation. The navigator's most indispensable and at the same time most delicate instrument is the mariner's compass, the operation of which depends upon the action of the earth's magnetism upon a freely suspended magnetic needle. This action is interfered with by the proximity of masses of iron, which are magnetized or easily magnetizable. For centuries wood and copper were almost the only materials used in shipbuilding, and the compass was little affected by the small amount of iron on board. Now, the magnetic force exerted by neighboring masses of iron causes a deviation of the needle which varies with

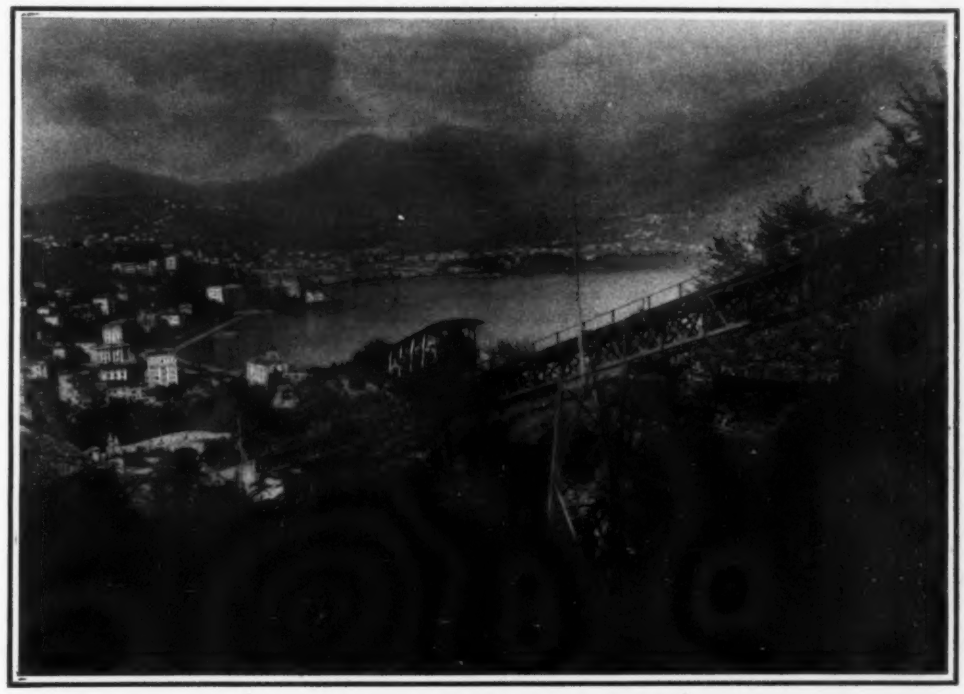
the position of the ship, as the magnetism of the iron assumes a direction intermediate between its original direction in the iron and the fixed direction of the earth's axis, with regard to which the iron is rotated as the ship turns. For many years these disturbing effects have been studied, and they are not yet completely understood. In practice the deviation can be measured for every reading of the compass and applied as a correction to all subsequent readings, as it remains fairly constant if the earth's magnetism is not greatly changed. It is also possible to compensate the disturbing influence of iron masses by placing other iron masses in positions where they will exert upon the compass a deviating influence in the opposite direction. In compasses properly made and placed in the best positions it is possible to compensate the deviation almost entirely in this way, but a second unfavorable influence of the surrounding iron masses remains, and is even increased. The iron which partially surrounds the compass protects it in a measure from the directive influence of the earth's magnetism, which consequently does not exert its whole effect. Inside the gun turrets of a warship the force of terrestrial magnetism is reduced to one-fifth of its normal value. As the horizontal magnetic force is feeble at the best, it is evident that a compass placed in such a position will not form a very reliable guide in navigation, especially when the vessel is rolling and pitching violently, but it is evidently necessary to place the compass by the side of the helmsman, who on a warship must be protected by iron armor.

Hence the problem of the deviation of the compass is a serious one. It can be solved most simply on merchant vessels by first selecting the most favorable place for the compass, and substituting wood or bronze or other unmagnetic metal for iron in the construction of neighboring parts of the ship. For parts requiring very great strength nickel steel containing 25 per cent of nickel can be employed. This alloy can be so treated as to be practically unmagnetic. On warships the case is different. Only a limited employment can be made of the non-magnetic and weaker materials, and other solutions of the problem must be sought. Two possibilities suggest themselves. The directive force of the earth's magnetism can be replaced by a force which is not affected by anything on board ship, or the compass may be set in a place as free as possible from magnetic disturbance, and its indications may be transmitted to the vicinity of the helmsman and there made visible. The former method is illustrated by the gyrostatic compass, which Dr. Anschuetz has brought to perfection after many years of labor, and which has now passed successful tests in the German navy. As this compass has been frequently described, it is not necessary to give here the details of its construction. Several other inventors are working on the same problem, but no practical tests of their instruments have yet been published.

The operation of the gyrostatic compass depends upon the tendency of a heavy body which is in rapid motion to maintain the direction of its axis of rotation unchanged. The center of gravity of the rotating disk is vertically under the point of suspension. When the disk is set in rapid rotation its axis tends to preserve its direction in space, while the earth, so to speak, turns under it. The force of gravity tends to keep the position of the disk unchanged with respect to the vertical. According to the gyrostatic law, the disk responds to the influence of a couple which tends to deflect its axis in one plane by a deflection in a second plane at right angles to the plane of the couple. Hence the rotation of the earth, instead of deflecting the suspended disk in a vertical plane, as it would do if the disk were not in rotation, causes it to move in a horizontal plane in such a manner that the axis of rotation comes slowly to the meridian plane, and the disk rotates in the same direction as the earth. In the absence of external disturbing influences and internal friction, the axis will preserve this position. The principle is simple, but many experiments and ingenious devices were required in order to construct a practical gyrostatic compass which gives reliable indications when placed on a moving ship. As it is a very delicate and expensive instrument, it will not be placed in exposed positions nor will many such compasses be employed on a vessel. It will rather be set up in a place where it can be protected from external influences as perfectly as possible, and its indications will be transmitted to other parts of the ship. The gyrostatic compass makes navigation entirely independent of the magnetism of the ship. It can be used in all latitudes which are commonly navigated, but its accuracy diminishes as the poles are approached. It possesses the disadvantage of being dependent upon the electric power by which the disk, weighing about 13 pounds, is caused to make 20,000 revolutions per minute. If the power fails the compass becomes useless, but on warships in normal conditions the evil is soon repaired. In battle, however, a permanent disability may occur, and recourse must then be had to the magnetic compass, which is still indispensable as a standard of comparison.

A second improvement in connection with the ship's compass consists in the transmission of its indications to a more or less distant point. These indications are best reproduced in the form of the ordinary compass card, with which every helmsman is familiar and which is very convenient to read. The chief difficulty is found in the establishment of a system which will be reliable on warships in battle. In peace it is possible to find suitable places for magnetic compasses, even on warships.

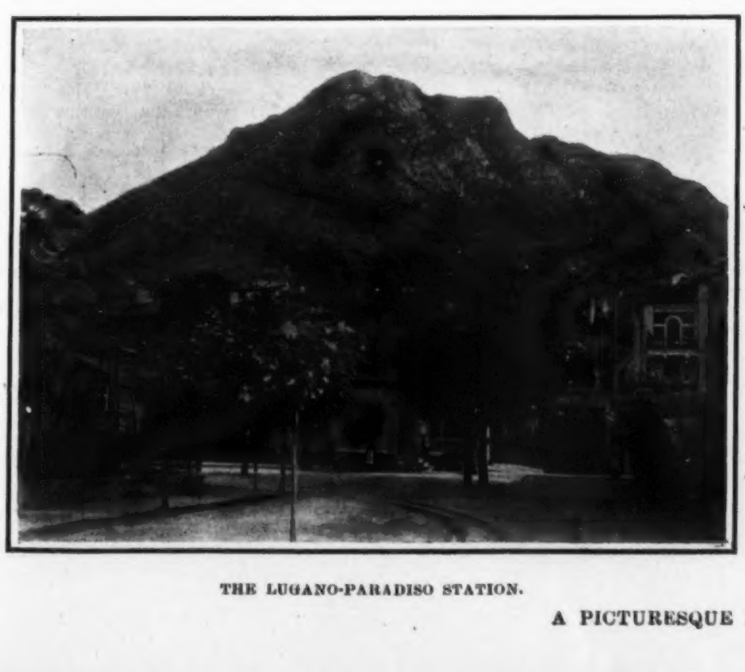
The trustworthiness of a compass is not affected solely by magnetic conditions, but also by other disturbing influences which are unavoidable on warships, such as the great variations of temperature in the vicinity of the furnaces, boilers, and steam pipes, vibrations of the ship caused by the discharge of the guns and by the engines and propellers, the proximity of dynamos and electric wires, and the rolling and pitching of the ship. Even on warships, however, available sites for magnetic compasses can be provided by special care in the construction of the vessels.



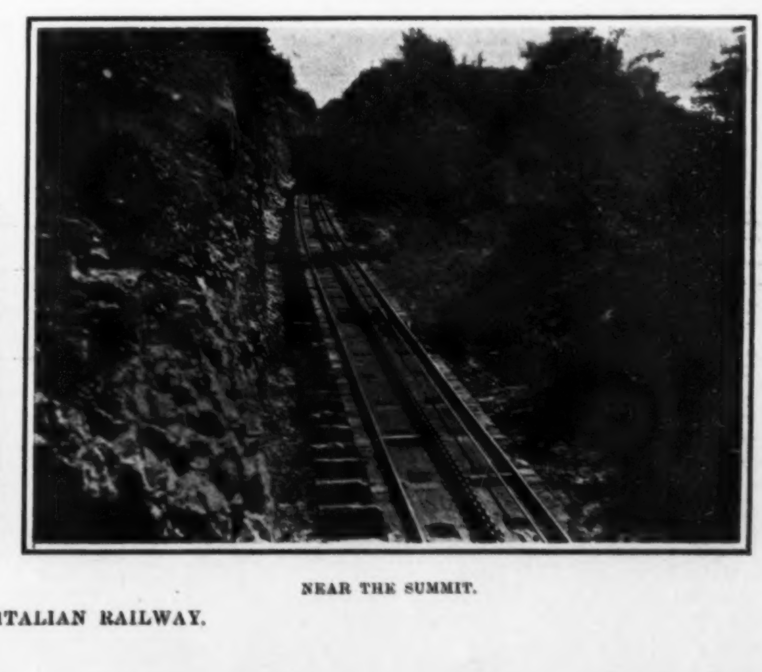
THE IRON TRESTLE AT CALPRINO.

In systems of transmission, care must be taken not to diminish still further the directive action of the earth's magnetism, and to make the receiving apparatus as light as possible, in order to avoid overtasking the driving compass. Unless the latter is of the gyrostatic type, therefore, mechanical transmission is impossible and an electrical method must be employed. The system may be based on various principles. The variation of conductivity caused by change of temperature may be employed in connection with the self-directing tendency of a circular electric coil freely suspended in a magnetic field, or resistances may be introduced into the circuit by the movements of the driving compass. Each of the systems hitherto devised has its good and bad points, and all of them are capable of improvement in point of accuracy. Even the apparatus employed in the navy is not perfect, as it could hardly be expected to become in so short a time, for instruments of this character require years of testing in all possible conditions before they become perfectly trustworthy. In its present condition, however, the apparatus increases the fighting value of the ship, because, so long as the vessel remains afloat and the driving compass is uninjured, it is possible to obtain compass readings at the point where they are needed, which is unsuitable for the location of the magnetic compass. Transmission systems have not been introduced in merchant vessels.

A third improvement in the use and application of



THE LUGANO-PARADISO STATION.



NEAR THE SUMMIT.

A PICTURESQUE ITALIAN RAILWAY.

the compass, and one which has hitherto been greatly neglected despite its importance, is presented by the registering apparatus which automatically records the course of the ship. Until recently no reliable registering apparatus was in existence, because the directive force of the earth's magnetism was required to operate the registering mechanism, and was thus overtasked. Not until the difficulties of the transmission of compass readings had been overcome was it possible to construct a reliable registering apparatus.

At present there is a system, patented in Germany, which makes upon a moving strip of paper a permanent record of the course followed by the ship. The tracing is not interrupted, but forms a continuous straight or curved line, and, therefore, shows all the minute variations of the course as accurately as the perfection of the system of transmission permits. The apparatus is, furthermore, so contrived that it will record either the actual or the corrected compass readings. Its operation is mechanical and may be described as follows: A disk, which moves in synchronism with the card of the driving compass, carries a strip of metal arranged in the form of two spirals, which turn in opposite directions and coalesce at points 180 deg. apart, thus forming a heart-shaped closed curve with an interior loop. This strip of metal carries a sliding piece attached to one arm of a lever, the other arm of which carries a tracing point which presses upon a moving strip of paper. As the disk turns, the sliding piece moves toward or from the center. The tracing point of the other end of the lever performs corresponding movements, and each of its positions corresponds to a definite azimuth of the disk, that is to say, to a definite reading of the compass. In this way the readings of one-half of the compass are recorded. A second lever, with a slider and a tracing point, is provided for the other half of the circle. The apparatus is so constructed that the magnetic variation and declination and other constant errors can be eliminated. In order to eliminate the deviation due to magnetic and other influences, which varies for different points of the compass, the strip of flexible metal is so attached to the disk that it can be deformed radially, and thus caused to deviate from the form of a regular spiral. The result, when the strip is properly adjusted, is that the true, instead of the apparent, compass reading is recorded. The employment of registering apparatus presents several advantages. At present, if it is desired to know in detail the course followed by the ship, it is necessary to keep an observer stationed at the compass, and it is very difficult for this observer to trace the actual mean course, because of the continual small deviations to right and left. The registering apparatus records every deviation which it receives through the transmitting system. A ship may be caused to swerve from the course by many influences, wind, waves, current, the working of the propeller, and the personal peculiarities of the helmsman. Of all these causes the last is the most potent. A good helmsman observes promptly the slightest tendency of the ship to swerve from the course, and by a slight movement of the helm the deviation is corrected. A poor helmsman makes the observation less promptly, the ship makes a detour, and a greater movement of the helm is required. The ship therefore oscillates to right and left of the course, so that the journey is prolonged, or the speed practically diminished. These errors accumulate and become important in the course of a long journey, causing steamers to lose days in time of passage and greatly increase the consumption of coal. If the actions of the steersman are continuously recorded, his peculiarities can be plainly demonstrated to him. It is better to prevent deviations from the course by good steering than to be compelled to correct the course by astronomical observations, and very possibly attribute erroneously to wind or current a deviation which is due chiefly to bad steering.

The record of the course, furthermore, furnishes very valuable evidence in cases of collisions and other accidents. At present the only evidence is the testimony of eyewitnesses, who are not apt to observe with perfect accuracy at the moment of danger. If the driving compass is of the magnetic type, the record also furnishes valuable information concerning the behavior of the compass in magnetic storms and other peculiar conditions. Several recording mechanisms can be operated by one driving compass.—Translated for Scientific American Supplement from Prometheus.

THE ORIGIN OF METEORITES.*

ARE THEY TERRESTRIAL PRODUCTS?

BY PROF. WILLIAM H. PICKERING.

By the term meteorite as distinguished from meteor, we refer to those bodies that actually strike the earth's surface. Meteorites are usually divided into two classes, those composed chiefly of iron, and those composed chiefly of stone. Of the 292 actually observed meteoric falls that took place during the last century, only twelve, or about four per cent, belonged to the first class, yet in our cabinets the two classes are represented in nearly equal numbers. The explanation of this strange anomaly lies in the fact that unless the fall has been actually witnessed close at hand, very few of the stony meteorites are ever found. Of 328 in the collection of the British Museum, 305, or 93 per cent, were seen to fall. This is partly because these bodies to ordinary inspection appear very like common stones, and therefore are not recognized as meteorites, and partly because owing to their physical and chemical structure they are readily decomposed by the action of the elements.

It has been suggested that if meteorites were formerly much more common than at the present day, we should find their remains, in the earlier geological strata. This does not necessarily follow, however, and it is probable that, owing to disintegration and decomposition, we should not now be able to recognize them as such, or distinguish them from the earlier basaltic lavas with which they are closely allied, both in chemical and in mineralogical composition. Beneath the sea, however, they have been preserved, and it is clear that in former times they must have been very numerous, for in the abysmal depths, where little recent sedimentary matter occurs, their remains are frequently found. Geikie in his "Text-Book of Geology," page 584, writing of this region, says: "In these deposits, moreover, occur numerous minute spherular particles of metallic iron and 'chondres' or spherical internally radiated particles referred to bronzite, which are in all probability of cosmic origin—portions of the dust of meteorites which in the course of ages have fallen upon the sea-bottom."

It is the almost universal custom to associate meteorites with falling stars, and to say therefore that they are of cometary origin. This relationship, however, is not as obvious, when we begin to examine into the case, as at first sight appears. A prominent difficulty is that the distribution of the meteorites throughout the year differs very materially from that of the falling stars and fireballs. While these last two are about twice as numerous during the latter half of the year as during the first half, the meteorites are more numerous during the first half of the year. From this we should infer that while perhaps all meteorites are fireballs, only comparatively few fireballs became meteorites. The dividing line between meteorites and falling stars then lies among the fireballs, the swiftly moving ones being allied to the falling stars, and the slowly moving ones to the meteorites.

It is now generally accepted that the crystalline and often conglomerate structure of these bodies proves them to be but the fragments of much larger bodies that have in some manner been destroyed, or from which they have otherwise become separated. Many believe that the crystalline structure of the iron meteorites indicates a slow cooling, while some say that the structures of the chondres of the stony meteorites must certainly have been produced by a very rapid crystallization due to a sudden exposure to a lower temperature.

It was formerly thought by some that these bodies might have been expelled from the sun. Although it is quite possible that solar explosions in past ages were sufficiently violent to project these bodies with the necessary cometary velocities, yet we cannot believe the sun to be the direct source of them since it is improbable that either solid stone or iron should ever have existed upon its surface or within its interior. Nor is it easy to explain how with such an origin the meteorites should have acquired their present orbits.

Some of the earlier cosmogonists referred their origin to the terrestrial or lunar volcanoes. This is manifestly impossible in the case of the earth, since even prehistoric volcanoes could not have expelled their products with such force that after leaving the confines of our atmosphere, they should still retain a velocity of over seven miles per second. Yet this is the speed required to prevent an immediate return to the earth's surface. Moreover, although volcanic eruptions in prehistoric times were undoubtedly more frequent and voluminous than at present, it is by no means certain for theoretical reasons, that they were then any more violent than they are to-day.

Meteors escaping from lunar volcanoes would not have to encounter a dense atmosphere, and furthermore their required parabolic velocity would be appreciably less. But even under the most favorable circumstances, in order to escape both the moon and earth a speed of over two miles per second would be required. That attained, they would then be controlled by the sun, and might be picked up at any later time by our planet in its orbit. The objection to this explanation is that no explosive volcanoes have ever been detected upon the moon, all the craters being of the engulfment type. It is therefore very improbable that such extremely violent explosions could have occurred there.

In the Astrophysical Journal 1901, xiv., 17, Prof. Chamberlin elaborates a very interesting theory explaining the origin of meteorites, and that of comets as well, as due to the destruction of one or more small planets by the near approach of another sun to our system. That some of the iron meteorites are allied to comets is implied in the fact that out of the twelve that were seen to fall during the past century one appeared during a conspicuous shower of Andromedids that occurred on the night of November 27th, 1885. Another appeared on April 20th, 1876, the date of the Lyrids, one of the four groups of meteors that are clearly associated with periodic comets. Moreover, meteorites have appeared during other star showers. In Clerk's "History of Astronomy," 1902, page 340, is mentioned one that fell during the brilliant meteoric display of April 4th, 1095. Its composition unfortunately is unknown. This also was probably a Lyrid.

No similar evidence has as yet been found, however, that the stony meteorites are allied to comets, and the fact that their monthly distribution bears no relation to that of falling stars which certainly are so allied, is distinctly contradictory to the hypothesis. The following table gives the relative frequency of falling stars, fireballs, very slowly moving fireballs, and meteorites, throughout the year. The first column gives the month, and the second the number of hours of observation during the seventeen years from 1873 to 1889 inclusive, devoted by Mr. Denning to the recording of meteors. M. N. 1890 L 410. The total number of meteors registered in that time was 9,177. The third column gives the horary rate deduced by him, omitting, however, all the Perseids. The fourth column is derived from the table published in the same volume, page 84, and gives the monthly distribution of 217 fireballs, chiefly as bright or brighter than Jupiter, observed by Mr. Denning during the thirteen years from 1877 to 1889 inclusive. He does not give the data necessary to compute the horary number, but the same constants as those given on page 410 above mentioned, have been adopted, and these will be sufficiently accurate for our purpose. The fifth column gives accordingly the computed horary number of fireballs, omitting the Perseids. The sixth column gives the monthly distribution of 29 of these fireballs whose motion he has described either as "very slow," or "very, very slow." The seventh column gives their horary number computed in the same manner as for the others, except that no correction has been made for the Perseids, which are known to move rapidly. The duration of visibility of ten of these fireballs was recorded, and extended from one to sixteen seconds. The last column gives the monthly distribution of 253 stony meteorites taken from the catalogue of the British Museum for 1896.

Month	Hrs.	Fall'g stars	Fireballs		Slow fireballs		Meteorites
Jan.	58	6.5	11	0.15	3	0.052	15
Feb.	28	4.9	1	.04	0	.000	18
Mar.	30	6.6	2	.07	1	.033	17
Apr.	96	6.6	7	.07	1	.010	26
May	58	5.2	3	.05	1	.017	36
June	64	4.9	6	.09	3	.047	30
July	157	11.3	28	.18	4	.025	15
Aug.	232	11.3	63	.18	3	.013	20
Sept.	154	10.3	27	.18	3	.019	21
Oct.	175	11.8	37	.21	5	.029	16
Nov.	140	11.3	25	.18	3	.021	19
Dec.	104	8.9	7	.07	2	.019	20

In the figure, the abscissas are taken from the first column of the table. The upper curve is plotted with the ordinates on the left, and gives the horary number of falling stars. The second curve is plotted with the ordinates on the right, and gives the horary number of fireballs. The lower curve gives the horary

* Popular Astronomy.

number of very slowly moving fireballs, the ordinates being those given on the left. The third curve gives the number of stony meteorites taken from the catalogue, the ordinates being given on the right.

It will be noticed from the two upper curves that the monthly distribution of falling stars and fireballs is very similar. The lower curve on the other hand shows that the relative frequency of slowly moving fireballs has greatly diminished in the latter half of the year, and in this respect resembles the curve giving the distribution of the meteorites. The first half of the lower curve is unreliable, being founded on only nine observations. The iron meteorites of the catalogue are distributed with considerable uniformity, one falling in each of the following months: January, March, April, May, July, August, November. They are too few in number, however, to permit us to draw any useful conclusions as to their monthly distribution.

While as we have seen meteorites cannot be the product of terrestrial volcanoes, yet as an alternative hypothesis to that of Prof. Chamberlin, it is suggested that the stony ones were all of them formed during the great cataclysm that occurred at the time that the moon separated from the earth. When the truly enormous pressure on the deep-lying terrestrial strata was suddenly relieved by the departure of the upper layers, which now form our moon, tremendous explosive energy must have been generated. Considerable portions of our atmosphere must have followed the larger flying masses, and the atmospheric resistance to the smaller ones, swept along at the same time, would have been much diminished. Although we can probably never definitely know just what occurred at this time, it is quite possible that considerable quantities of the smaller masses were carried along by the blast of escaping gases, and were projected to such distances as to entirely free themselves from the attraction of our planet. This implies a solid crust for the earth at the date of birth of the moon, which previous investigations of the place of origin of that body seem to justify.

In order to fix our minds, let us assume that at the time of the removal of this matter from the earth's surface, one-tenth of one per cent of it was projected with a more or less parabolic velocity into space. If concentrated into one piece, this would have formed a sphere of the density of the moon, and 200 miles in diameter. Let us suppose, however, that instead of forming only one piece it was really concentrated into a great number of little moonlets, to adopt a term suggested by Prof. G. K. Gilbert, varying from a few miles in diameter downward.

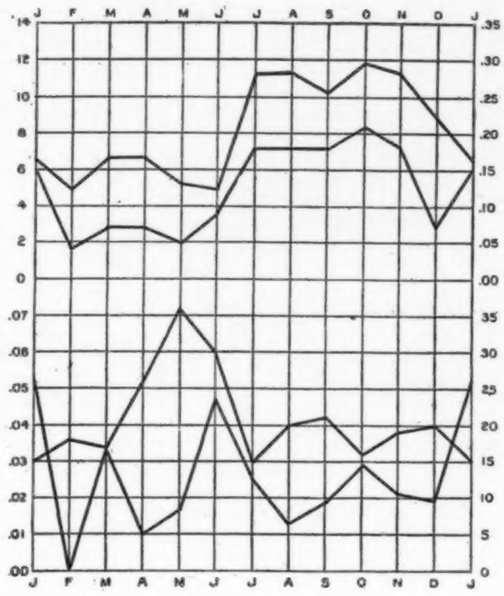
Those moonlets whose velocities were only elliptic, and whose courses at the start were so perturbed that they did not at once return to the earth, would continue to revolve about the center of gravity of the earth and moon, which in those days were close together. Generally they would move in very eccentric orbits. Those moonlets whose velocities were hyperbolic would free themselves from our planet, but still could not escape the sun, and would therefore revolve about it in orbits coinciding more or less closely with that of the earth.

Since all the moonlets that we are now considering were moving with velocities approximately parabolic with regard to the earth, and since they would be constantly meeting both that body and the moon, their orbits would be subject to most violent perturbations, constantly shifting them back and forth between hyperbolic and elliptic conditions. Moreover, they would all of them sooner or later pass near enough to one or the other of the two large bodies to be minutely fractured by it, in the manner so fully explained by Prof. Chamberlain in the paper above mentioned. It is suggested that all the stony meteorites, and perhaps also some of the metallic ones, were formed in this manner.

In support of this view of their terrestrial origin we have the fact that twenty-nine terrestrial elements, including helium, have so far been recognized in meteorites, ten of them being non-metallic. No new elements have been found. The six which occur most frequently in the earth's crust, named in the order of their abundance, are oxygen, silicon, aluminium, iron, calcium, and magnesium. The eight most commonly found in the stony meteorites are these six, besides nickel and sulphur.

Nearly all the stony meteorites contain some metallic iron, and some of them contain large quantities of it. But this is also true of some of our basaltic lavas. Indeed, large masses of iron have been found in ledges upon the Greenland coast. Some of this iron contains over six per cent of nickel, but much larger proportions have been discovered in New Zealand, Piedmont, and Oregon, where considerable quantities of the nickel iron alloys have been found. According to Farrington, of the twenty-one minerals recognized in meteorites, fourteen have been found in our volcanic products.

On the other hand quartz, one of our most common minerals, has not hitherto been detected in meteorites. It has been shown by Sir John Murray, however, that when silicates are exposed to the action of carbonic acid for any length of time, the bases are changed to carbonates, and silica is set free. These favoring conditions have existed on a large scale in the case of the earth, but certainly do not exist on meteorites. This would accordingly seem to answer this objection. Another difficulty which has been raised to the terrestrial origin of meteorites is that over ninety per



cent of the stony ones contain chondres, and that these latter are never formed under terrestrial conditions. They are supposed to be due to rapid crystallization in a suddenly cooled mass, and naturally these conditions could never occur within the earth's interior. If, however, the molten matter were suddenly expelled by a violent explosion into interplanetary space, we have the very conditions which are supposed to be required for their formation.

Returning now to orbital considerations, if the dates of fall of the 253 stony meteorites recorded in the catalogue of the British Museum were uniformly distributed throughout the year, we should find that two meteorites would fall during every three days. In point of fact the distribution is not at all uniform, and we find certain dates when such falls seem to be extremely prevalent. This is illustrated in the accompanying table where the first column gives the day of the month, and the other columns the number

DISTRIBUTION OF STONY METEORITES THROUGHOUT THE YEAR.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	2			1	1		1			1		1
2		1			1	2		1				1
3	1	2		1		1	1		1	1		
4			1			3	1	1	2		1	
5				2	1			2	2	2	2	1
6			1	2		1				1		1
7				2		1		2	2	1		1
8					3		1	1		1		
9		1		1	3	1	1		2			1
10		3		2				1	1		1	1
11				2	2		1	2		1	1	
12		1	2	1	1	3	1	1		1	1	
13		1		1	2	2			2	4		3
14			1		3	1	2	2	1	1		1
15	1	2	1	2		1	1					
16	1	3	1			2			1		1	
17				1	1	2	1		1			
18		1		1		2		1				
19	2	1	2	1	2	1			1		2	1
20			1		3						2	
21					1				1	1		1
22			1		3	1	1		1			2
23	2				1		1		1		1	
24				1	2		2				1	1
25		1	2			1		2			1	1
26			1	3	1	1			1		1	
27	1				2				1		2	3
28	1	1	2	1		3						
29	1			1		1		2				
30	1				1			1			2	
31	2		1					1		1		
Total,	15	18	17	26	36	30	15	20	21	16	19	20

of meteors that fell on each day of each of the twelve months. An examination of the table will show that during the three days from May 20th to 22nd inclusive, seven meteorites were seen to fall. Six meteorites are found in each of the three-day periods from April 5th to 7th, May 9th to 10th and 12th to 14th, June 2nd to 4th, 12th to 14th, and 16th to 18th, and October 12th to 14th.

Of the four meteoric swarms definitely known to be related to comets, the Andromedids, owing to the rapid shifting of their node, change their date of appearance so rapidly, that they cannot be considered to advantage in this connection. But if the stony meteorites were really associated with comets, we should expect to find that a slight excess of them would fall at about the dates of the other showers. The Lyrids appear April 20th. On the three days from April 19th to 21st, we find but one stony meteorite recorded, or less even than the average. The Perseids reach a maximum August 10th. On the three days from August 9th to 11th, three stony meteorites fell, or a little better than the average. On the preceding fifteen days, however, when Perseids are unusually abundant, only seven stony meteorites fell. The Leonids reach a maximum on November 14th. On three days from November 13th to 15th not a single stony meteorite is recorded.

Another reason for dissociating the meteorites from comets is that the fireballs from which they are seen to originate, seem, as compared to falling stars, to move through the air slowly, and to be very long enduring in their flight. And this is true in spite of their comparative proximity to the earth. If they arrived with the speed of falling stars, we should at least expect them to begin their visible flight at high speed. Such, however, is certainly not the case, no great change in speed throughout their course being noticeable. This slow speed implies a small aphelion distance, not far outside of the earth's orbit. Such an orbit would be unlike that of any known comet.

Again, the iron Andromedid above mentioned, which fell in 1885, arrived hot, as a "ball of fire." So did the other iron meteorites of 1835 and 1876, the former carbonizing the vegetation where it fell, and the latter an hour after its fall being still hot. While perhaps all the stony meteorites are self-luminous, and therefore intensely heated in the upper layers of our atmosphere, yet their luminosity generally if not always ceases before they reach the ground, where they often arrive at a comparatively low temperature, even when unfractured and of considerable size. In some cases, they have been handled within a few minutes after their fall. In one case, that of the Shelburne meteorite of 1904, it is recorded that the vegetation on which the stone fell was left green and uncharred. The stone itself weighed thirteen pounds. In several cases, the velocity with which the stone struck has been computed. It has ranged in general from 400 to 600 feet per second. The Hassle stones fell on thin ice, from which they rebounded without even fracturing the ice.

It, therefore, appears that the iron and stony meteorites differ from one another in other ways besides their composition. That some of the former are associated with falling stars, and therefore with comets, certainly seems plausible. That the latter are not associated with them seems probable, and if so, whence can they have come if not from our own earth?

Eggs which have been preserved by any method may acquire peculiarities of appearance and flavor due to physical and chemical changes, some of which are caused by bacteria. Authors differ in regard to the nature of the bacilli contained in fresh eggs, but they agree in stating that few eggs are free from them. Various methods of preserving eggs have been attempted, the object in nearly all methods being to exclude air. Experiments made in Germany give the following comparative results, the eggs, in all cases, having been "laid down" in June and opened in the following February. The percentage of spoiled eggs is given in each case. Eggs kept in bran, 70; coated with paraffine, 70; immersed 15 seconds in boiling water, 50; varnished with potassium silicate, 40; varnished with gum lac, 20; packed in wood ashes, 20; packed in potassium permanganate, 20; coated with vaseline, none; kept in lime water, none; kept in solution of potassium silicate, none. In the most recent method of preservation, cold storage, it is especially necessary to inspect the eggs carefully at the beginning, as one spoiled egg may contaminate a great many. The selected eggs are then placed in open racks in rooms where the temperature is kept below 30 deg. F. in order to prevent putrefaction, and above 29 deg. F. in order to prevent freezing, which would solidify the yelk and crack the shell. The humidity of the air should be as nearly as possible 78 per cent. Excessive moisture causes molding, and excessive dryness of the air produces too much desiccation. Cold storage appears to preserve the egg in its original microbial condition, neither destroying existing bacteria nor permitting the development of new ones.

Patina Tincture for Electro-plated Objects.—The articles to be bronzed must be made perfectly clean by pickling and the following mixture applied with a brush: 20 parts castor oil, 80 parts alcohol, 20 parts soft soap, 40 parts water. The objects coated with this mixture are allowed to lie for 24 hours, and the patina will then be formed. If the tincture is allowed to remain longer on the objects, all shades may be gained from Barbadian bronze to antique green. The articles, after bronzing, are dried in warm saw-dust and finally coated with a very thin varnish.

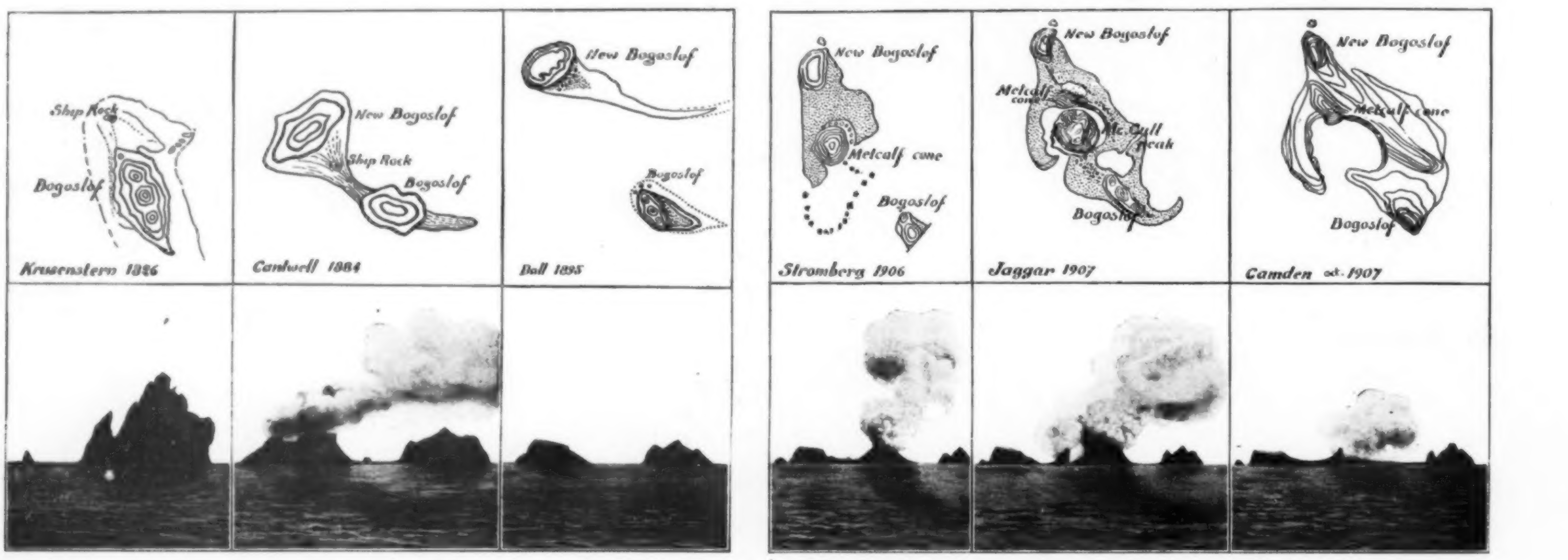
THE BOGOSLAV ISLANDS.

A GEOLOGICAL CURIOSITY.

The changes of form of the island, or islands, of Bogoslav, of the Aleutian archipelago, near Bering Strait, have long been celebrated. The most remarkable feature of these transformations is the rapidity with which they are accomplished. An article by Capt. F. N. Munger, published in a recent issue of the Geographical Magazine, gives interesting information of these changes, which is here summarized.

The accompanying illustrations, showing the appearance and configuration of the islands at various epochs between 1826 and 1907, have been made from illustrations and data published in the Bulletin of the American Geographical Society for 1908.

The changes have been caused by volcanic eruptions. The island was discovered in 1790 by the Russian admiral Bogoslav, for whom it was named. The Americans renamed it Castle Rock. The most remarkable change occurred in the winter of 1886-7, when a new island appeared, about three miles northeast of the old one. For several years the two islands were connected, at intervals, by a visible strip of land, which at other times disappeared beneath the waves. A third cone appeared between the other two, in 1905-6, and was called Metcalf or Perry Cone. In 1906-7 a fourth cone, McCulloch Peak, appeared, but on October 15th, 1907, it had vanished and was replaced by a great bay of hot water. It is supposed that the peak sank into the sea on September 1st, 1907, when observers on the neighboring island of Unalaska saw a great cloud of smoke hanging over Bogoslav. Finally, on July 7th, 1908, it was discovered that Perry Cone had also vanished, leaving the two islands, Old and New Bogoslav, again connected only by a narrow strip of land.



APPEARANCE AND CONFIGURATION OF BOGOSLAV ISLANDS AT VARIOUS DATES.

ALUMINIUM BRONZE.

Deville, in 1859, gave the name aluminium bronze to an alloy of copper with 10 per cent aluminium. This alloy has a beautiful golden color, is not attacked by the air or by sea water, does not smell of copper when handled, and possesses remarkable mechanical properties which resemble those of cast steel. It found immediate application in jewelry and the manufacture of household utensils. The families of Deville's friends still possess objects of aluminium bronze which have preserved the luster of gold. Recent researches on the alloys of copper and aluminium have confirmed Deville's assertions in regard to the tenacity, hardness, and permanence of the alloy containing 10 per cent of aluminium. Hence H. Le Chatelier, in the Revue de Métallurgie, expresses surprise that this alloy is so little used. In Deville's time its extensive employment was prohibited by the high price of aluminium, but now aluminium bronze should cost less than nickel and little more than copper. At present it is used chiefly for propeller blades and other objects exposed to sea water. From the researches mentioned above it appears that copper and aluminium form at least three definite compounds, Cu_3Al, CuAl, and $CuAl_2$, and two eutectic alloys, containing 92 and 34.5 per cent of copper, the last named alloy fusing at 995 deg. F. The alloy which contains 10 per cent of aluminium is a solid solution of the compound Cu_3Al or perhaps of a fourth compound, Cu_4Al. Valuable mechanical properties are possessed only by alloys containing from 8 to 11 per cent of aluminium and by an alloy containing 95 per cent of aluminium. Cast aluminium bronze, cooled rapidly, acquires a tensile strength equal to that of Bessemer steel. The elongation before rupture is also similar to that of steel and both metals are proved by the microscope to be mixtures of particles of different degrees of hardness. Aluminium bronze can be forged and rolled with ease, especially when hot, as Deville proved half a century ago, when cast steel was practically unknown and the famous chemist hoped to find a material suitable for the making of cannon, for which purpose, indeed, aluminium bronze has been experimentally employed with success.

MAN AS HE OUGHT TO BE AND MAN AS HE IS.

In a paper read before the Anthropological Section of the British Association for the Advancement of Science Prof. John L. Myres, M. A., F. S. A., President of the Section, dealt with the "Influence of Anthropology on the Course of Political Science," quoting examples sufficient to show how intimately the growth of political philosophy has interlocked at every stage with that of anthropological science. Each fresh start on the never-ending quest of "Man as he ought to be" has been the response of theory to fresh facts about "Man as he is"; and meanwhile the dreams and speculations of one thinker after another—even dreams and speculations which have moved nations and precipitated revolutions—have ceased to command men's reason when they ceased to accord with their knowledge. And we have seen more than this. We have seen the very questions which philosophers have asked, the very questions which perplexed them, no less than the solutions which they proposed, melt away and vanish, as problems, when the perspective of anthropology shifted and the standpoint of observation advanced. This is no new experience, nor is it peculiar either to anthropology among the natural sciences or to political science among the aspects of the study of man. It is the common law of the mind's growth, which all science manifests, and all philosophy. And now I would make one more attempt to put on parallel lines the course of political thinking. It is not so very long ago that a great British administrator, returning from one of the gravest trials of statesmanship which our generation has seen, to meet old colleagues and classmates at a college festival, gave it to us as the need he had most felt, in the pauses of his administration, that there did not exist at present any adequate formulation of the great outstanding features of our knowledge (as distinct from our creeds) about human societies and their mode of growth, and he commended it to the new generation of scholarship, as its highest and most necessary task, to face once more the question: What are the forces, as far as we can know them now, which, as Aristotle would have put it, "maintain or destroy states"? But if a young student of political science were to set himself to this life-work, where could he turn for his facts? What proportion of the knowable things about the human societies with which travelers' tales and the atlases acquaint him could he possibly bring into his survey without a lifetime of personal research in every quarter of our planet? I have in mind one such student setting out this coming session to investigate, on the lines of modern anthropology, the nature of authority and the circumstances of its rise among primitive men, and the difficulty at the outset is precisely as I have described. In the case of the "black fellows" of Australia such a student depends upon the works of some four or five men, representing (at a favorable estimate) one-twentieth even of the known tribes of the accessible parts of that continent. For British South Africa he would be hardly better served; for British North America, outside the ground covered in British Columbia by Boas and Hill-Tout, he would have almost the field to himself; and the prospect would seem to him the drearier and the more hopeless when he compared it with things on the other side of the forty-ninth parallel. Now, our neighbors south of that line have the reputation of being practical men; in other departments of knowledge they are believed to know well "what pays." And I am forced to believe that it is because they know that it pays to know all that can still be known about the forms of human society which are protected and supervised from Washington that they have gone so far as they have toward rescuing that knowledge from extinction while still there is time. The Bureau of Ethnology of the United States of America is the most systematic, the most copious, and, I think, taking it all in all, the most scientific of the public agencies for the study of any group of men, as men. The only other which can be compared with it is the ethnographical section of the last census of India, and that was an effort to meet, against time, an emergency long predicted, but only suddenly foreseen by the men who were responsible for giving the order. Thus, humanly speaking, it is now not improbable that in one great newly-settled area of the world every tribe of natives which now continues to inhabit it may at least be explored, and in some cases really surveyed, before it has time to disappear. But observe, this only applies to the tribes which now continue to exist; and what a miserable fraction they are of what has already perished irrevocably! It is no use crying over spilt milk; the only sane course is to be doubly careful of whatever remains in the jug.

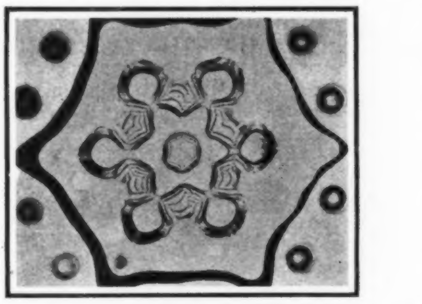
Matt Gold or Matt Luster on Porcelain.—The glazed surface to be painted is first completely coated with a metallic color. This may consist of red lead, quartz, borax, and a metallic oxide color rubbed down with dammar varnish. When this coating is dry, the design is drawn on it with colored oil of cloves. After a few minutes the oil is wiped off; at the same time the underlying coat of color is removed. This operation is known in Germany as the "Aussprengen" of the design. The matt color is then burned in in the muffle-furnace. The object is then placed in very dilute fluoric acid (1,000 parts of water and 3¾ parts of strong fluoric acid) or the decorated surface is painted with it. This corrodes away the matt color. If the surface to be decorated is then coated with bright gold or bright luster and this coating burned in in the muffle furnace, it will be matt on the places where the matt color was corroded off and otherwise bright. The matt gold has a light color and is as durable as the simultaneously produced bright gold.

OSMOTIC PRESSURE AND LIVING CELLS.*

SOME EXPERIMENTS WITH SOLUTIONS.

In the very interesting chapter on the "Problems of Solution" which appears in Mr. W. C. D. Whetham's "The Recent Development of Physical Science" (John Murray) he defines the importance of this question. We quote from the newly-published second edition: "To one inexperienced in the problems which confront the workers in the world of natural science, the whole question of solution and its attendant phenomena may appear of small account. Yet the study of these phenomena and the unraveling of their intricate connections are of fundamental importance . . . More and more the reactions of inorganic substances, whether liquid or solid, are referred to their properties in a state of solution, while every process of life to be examined by the biologist seems capable of interpretation only through attention to the conditions thereby involved. Moreover, most chemical actions, especially those examined easily in the laboratory, occur between substances one or more of which are actually in the liquid state; while the application of physical conceptions to the problems of living matter chiefly depends on the knowledge we possess of the physics and chemistry for ordinary solutions."

As long ago as 1877 Pfeffer, following on the researches of Traube in the organic cells of plants and their semi-permeable membranes, discovered certain laws governing the osmotic pressure of solutions: that is to say, the tendency of a solution to press against its surrounding membranes. In 1885-6 Van t'Hoff drew attention to the importance of osmotic pressure and showed that (1) the osmotic pressure was inversely proportional to the volume in which a given mass of sugar was confined in solution, and (2) that the absolute value of the pressure in the case of a solution of sugar was the same as that which would be exerted by an equal number of molecules of a gas when placed in a vessel having a volume equal to that of the solution. For instance, a quantity of gas of the same molecular concentration as a one per cent solution of sugar would exert a pressure equal to that which Pfeffer had observed for the osmotic pressure of a sugar solution against the sides of a membrane-like receptacle containing it. Therefore dilute solutions appear to follow the same rule as gases; and the pressure depends on the number of molecules present, not on their nature.



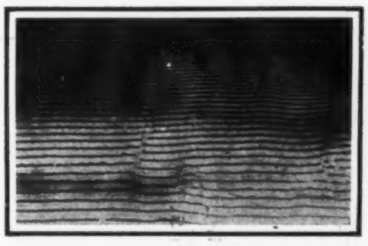
A PATTERN PRODUCED BY THE DIFFUSION OF LIQUIDS ON ONE PLATE. THE DROPLETS OF OTHER LIQUIDS ARE SHOWN.

OSMOTIC GROWTHS OF MINGLED KINDS.

Produced by the described method of introducing differentiated sugar and metal solutions into a copper solution. Some of the rods which are thus induced to grow end in spheres, others in cones. The herbivorous appearance of some of the rods and tendrils is very noticeable.

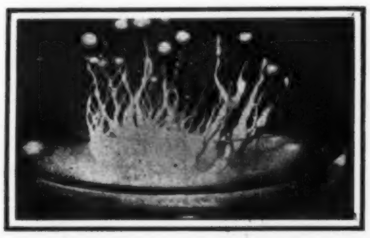
* Knowledge and Scientific News.

Some of the more popularly illustrative results which have followed from the study of the interplay of solutions appear in the photographs made in the laboratory of Prof. Leduc, of Nantes, which have been sent to us by Dr. Alfred Gradenwitz.



A DIFFUSION GRATING FURNISHING RESULTS SIMILAR TO THOSE OF A DIFFRACTION GRATING.

Dr. Gradenwitz writes: "Prof. Leduc having introduced a drop of sugar solution containing traces of potassium ferrocyanide into a dilute copper sulphate solution, found, as Traube had found, that the drop of sugar solution covered itself with a copper-ferrocyanide membrane, pervious to water, but impervious to sugar. Physical conditions similar to those in a naturally germinating cell, within which there is high osmotic pressure and strong cohesion, were thus obtained, the contact of the potassium ferrocyanide with the copper sulphate producing a semi-pervious sheath. Under the influence of the difference in osmotic pressure between the drop and the liquid into which it is immersed, the water would percolate through the surrounding membrane which the sugar was unable to traverse. The cell would thus grow on, while, after the lapse of some minutes, from some point of its surface would spring up a bud. This would be surrounded immediately by a copper-ferrocyanide membrane. On the top of this bud would be produced another bud, and on this a third one, and so on, each bud constituting a cell, all of which would arrange themselves slowly in a continuous row, forming a hollow rod, the length of which would exceed by more than ten times the diameter of the original cell, of which the others were offsprings. The artificial cells absorbed from the surrounding medium the substance required for their growth, and thus produced the bulky growths exhibited.

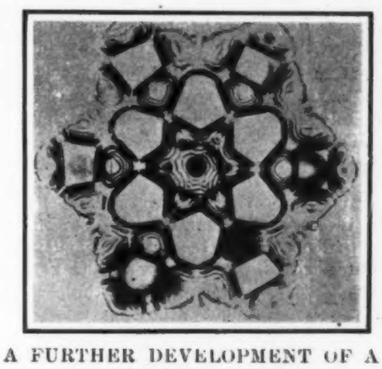


A PLANT-LIKE CHEMICAL GROWTH ENDING IN SPHERES.

A droplet would sometimes be projected in the course of the experiment, being entirely detached from the original drop, in order afterward to grow on and give off buds and growing rods, which finally produced a form similar to the original one. At the recent exhibition of the French Physical Society, Prof. Leduc showed a number of examples of the way in which the diffusion of solutions could be made to assume not only plant forms, but decorative patterns.

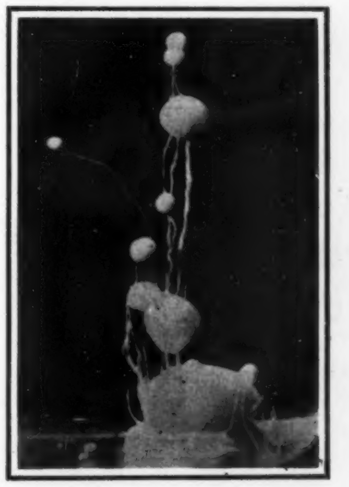
The following particulars will enable anyone to obtain similar figures of diffusion: On a glass plate are poured out five cubic centimeters of a 10 per cent gelatine solution to which has been added a drop of a saturated solution of different composition (preferably ammonium chloride, bromide, or iodide). On the gelatine thus prepared are arranged symmetrically some drops of various solutions, such as calcium nitrate, silver nitrate, potassium citrate. If this plate be allowed to rest on a horizontal surface the liquid drops are seen to diffuse gradually, generating the most surprising effects of form and color. Care should be taken to protect the plate when drying against any shock; the picture is eventually glued on pasteboard, like a photographic print, in order to be used in practice as a decorative pattern. Certain substances will produce by their diffusion lines of equal distance—alternately transparent and opaque—the thickness of which varies from some tenths to less than 1/1,000 of a millimeter. If their thickness is intermediary between 1/100 and 1/1,000 millimeter the patterns are full of networks of lines, and rectilinear or circular gratings, giving the most splendidly colored diffraction spectra, are easily obtained. These gratings are obtained with a large number of substances; especially beautiful samples are produced by allowing a mixture of saturated solutions of potassium phosphate and carbonate in equal parts to diffuse. In fact, the effects then obtained are quite similar to the scintillation of mother-of-pearl.

Now, as pointed out by Leduc, all living tissues show the same kind of network structure. In fact, not only in mother-of-pearl, but in the wings of beetles, feathers of birds, muscles and sinews of man, and in many other living substances, are met the same structure and color effects whose production no physical force so far sufficed to explain. In addition to its scientific interest, the process above described is obviously of the highest practical importance, allowing as it does the most splendid pearly photographs to be produced by coating the gelatine of the photographic plate at 35 deg. C. with a gelatine layer, containing traces of calcium nitrate on which drops of a mixture of calcium phosphate and carbonate are spread out.



A FURTHER DEVELOPMENT OF A DIFFUSION PATTERN.

The prevailing colors of marine organisms, both animal and vegetable, vary with the depth at which they live. The principal factors which determine this variation are the decrease and change of color of the illumination. The violet and blue rays of sunlight are quickly absorbed, while the red rays penetrate to much greater depths. The sea can be divided into arbitrary zones or strata, each distinguished from the others by the color of its illumination. The depths of these zones vary with the latitude and have not been very exactly determined, but in general the red rays preponderate at all depths greater than 60 or 70 feet. The colors of marine animals and plants are adapted to the color of the light which reaches them. It is well known that green, brown, and red algæ live at different depths, and that red algæ only are found at depths exceeding 300 feet. In regard to animal organisms Oersted distinguishes six zones, in which the prevailing colors of animals are the following: 1 (the superficial stratum) blue and violet; 2, gray and variegated; 3, green; 4, yellow and brown; 5 (extending to 500 feet), red; 6 (extending to the sea bottom), colorless.



SPHERE-LIKE TERMINALS OF THE GROWTH.

THE USES AND DATES OF ANCIENT TEMPLES.*

AN INTERESTING ASTRONOMICAL INVESTIGATION.

BY SIR NORMAN LOCKYER.

I propose in the present article to make some very general statements concerning the work so far done on the orientation of ancient temples, and to bring together some of the chief conclusions to which it has led.

I may begin by stating that the inquiry has been carried on at intervals during the last nineteen years—that is, since March, 1890—when I observed the magnetic bearing of the temple axis of the Parthenon. From 1891 to 1894 the research was almost entirely limited to Egypt. "The Dawn of Astronomy," published in 1894, gives the result.

The first definite conclusion arrived at deals with the use of the temples; why they were built, and for what purpose. It was found that the Egyptians carefully built their temples so that the rising and the setting of certain stars, and of the sun at certain times of the year, could be watched along the temple axis by the priest in the sanctuary.

It was not until after my first winter in Egypt that I learned that Nissen, of Bonn, had anticipated me in suggesting that this might have been so, and that several references to the practice which I had made out occur in the inscriptions.

One of the chief difficulties in the Egyptian work arose from the fact that in most cases the date of the foundation of the temples was unknown. There were, however, some notable exceptions where the results of the orientation theory could be compared with records, and in these there was a perfect agreement, which also enlightened us on the method employed by the Egyptian astronomer-priests for reducing to a minimum the disadvantageous effects of the change of the places of stars brought about by the precessional movement.†

The next conclusion dealt with the actual astronomical observations made by the ancient Egyptians. They were of three classes: (1) To determine the time at night. The stars used for this purpose I have called "clock-stars." (2) To observe a star rising or setting "heliacally"—that is, about an hour before sunrise on the chief festivals. (3) To determine when the sun had reached a certain part of its yearly path at which the festivals occurred.

For (1), as they had no instruments, they used a star rising near the north point of the horizon, and watched its movement round the pole; one quarter of its path would, of course, represent six hours, and so on. The stars so used were the brightest ones in the Great Bear and the Dragon. Stars rising near the south point of the horizon were also observed, and, doubtless, for the same purpose. For (2) any bright star rising or setting at the proper time between the north and south points would do; as a matter of fact, they used Capella, Spica, the Pleiades, Sirius, a Centauri, Canopus, and others. For (3) they commenced with a year beginning in May—the "May year," the first used in Britain, and still determining the quarter-days in Scotland; later they passed to the "solstitial" year, June 21, the beginning of the Nile rise and the longest day, being the *new* new year's day. This is the origin of our present English year.

The inquiry thus begun in Egypt was subsequently carried on in Greece by Mr. Penrose with admirable results, because there he was able to deal with temples the foundation dates of which are known within narrow limits.

The first attempts to apply the orientation theory to British monuments was made by Mr. Penrose and myself in 1901 at Stonehenge.

At the first blush there appears to be no resemblance between the Egyptian and Greek temples and the British stone monuments, but a careful study of both shows that this view is an erroneous one.

The study of the British monuments from the astronomical point of view has enabled us to grasp one object which, in spite of their varied forms and complexities, they all had to fulfill. It also enables us to classify them, and their classification not only suggests the order of their evolution, but shows their strict relationship to the Egyptian temples. This was the next advance. The demonstration is as follows:

The simplest of our ancient British stone monuments is represented by what is called a stone-row or avenue; good examples of these are to be seen at Merrivale; one is a single line of stones; the other is a compound avenue consisting of two double lines of stones running parallel with each other at some distance apart. The most famous compound avenue in our own country is that of Challacombe, on Dartmoor, which consisted once of eight rows of stones. I am sorry to say only two or three rows now remain.

Avenues were in some cases built of earth instead of stones; one at Stonehenge can still be studied; it extends toward the northeast from the center of the temple and naos.

The next form we have to consider after the avenue is the cromlech or dolmen—that is, the skeleton of an old barrow. Here again we get the gradual elaboration from a single cromlech to compound ones. A good example of the former is that at Trevethy, in Cornwall. In this, which consists of very large stones, the only entrance into the chamber is provided by a small portion cut out at the bottom corner of one of the stones. There is another very good example called the Devil's Den, near Avebury, which is rather more simple than the cromlech at Trevethy. It consists of one big stone supported by three others.

Another kind of monument called a cove must be regarded as an uncovered cromlech. It consists of three stones occupying three sides of a square, the open side indicating the direction; the finest example is at Avebury.

Cromlechs do not always occur singly. At times they are compounded into pairs or triplets, as at Plas Newydd.

We next find a combination of the avenue and cromlech. In this form the direction of the opening of the cromlech is defined by marking and extending it with a double line of stones. We thus get a creep or alley-way, or *allée*, as the French archæologists call it, and this may be either open or covered—*allée ouverte* or *allée couverte; fougou* is the Cornish term for the latter form.

The best example that I have seen of this combination of avenue and cromlech in Britain is that at Bryn Celli Ddu. This, like the avenue at Stonehenge, looks out to the northeast of the horizon; in fact, it is practically parallel to that avenue. The most perfect example of a barrow containing a cromlech with an alley-way is at Maeshowe, in the Orkneys. The cromlech is in the center of a still existing mound; it is a very elaborate one, with side (sleeping) chambers and a small chamber at the end, and a long alley-way which points to a menhir not far away called the "Barne Stone," and to the place of sunset in December, twenty days from the winter solstice.

The most compound example of avenues and cromlechs that I know of as yet is one of which photographs and particulars have recently been sent to me by Capt. Devoir, of the French navy; in it we have three cromlechs and three alley-ways, using the same outlook, and, doubtless, once covered by one barrow.

One alley-way is directed to the sunrise in May, another to sunrise at the winter solstice, and there is another directed to a "clock-star" rising near the north point, so that, in association with one barrow, we have three distinct and well-marked alleys in directions with which we are perfectly familiar.

This oneness of aim which the orientation theory enables us to discover leads us further.

In the avenues, alley-ways, and cromlechs we are absolutely face to face with the ground plan of Egyptian temples, so much so that there can be no question that those who built those magnificent monuments in Egypt some 2,000, 3,000, or 4,000 years B. C. got their ideas of the buildings they wished to erect from the traditions of people who built cromlechs and who had lived in and used them.

A general plan of Thebes shows how in Egyptian architecture, in a country of wonderful civilization, large population, and infinite wealth, we get a tremendous elaboration of the avenue; each temple is provided with one, long or short, leading outward from the pylon.

The avenue, which in our case is built of rough stone, is elaborated into long lines of beautifully carved sphinxes, and, further, if we study the most elaborate Egyptian temples, we see there are, in the temple itself, very many openings in one straight line in various walls; in some places we have an *allée ouverte*, and in others an *allée couverte*.

These all lead to a closed chamber at the end, a darkened chamber, the naos or the holy of holies, which is nothing but a glorified cromlech.

The temple access never pierces the end of the closed chamber any more than the wall was pierced at the back of the cromlech, but it led to a darkened chamber, so that here we have the closest possible relationship from the architectural point of view between the British cromlech and the most elaborate temples at Thebes, while from the astronomical point of view the similarity of use is obvious.

So much, then, for the intimate connection between the avenue and the cromlech, however simple or complicated either may be, and the strict relationship of both to the Egyptian temples.

But there is another and completely different set of ancient monuments still to be classified. I refer to circles, which, like the avenues and cromlechs, may be simple or compound. Archæologists so far have not noticed the close relationship of circles with avenues and cromlechs, for the reason that the circles to which their attention has been almost entirely confined only represent one part of the apparatus. When we consider a circle and its outstanding stone indicating a certain direction, the strongest astronomical resemblance to the alignments of avenues and cromlechs is at once apparent.

There is no doubt that the circle represents an enormous advance in astronomical knowledge, possibly, to a certain extent, connected with the building conditions brought about by the poverty or the economical ideas of the people who constructed them. In densely populated and rich Egypt a temple was devoted to the rising or setting of one heavenly body, whether star or sun, the place of rising or setting being indicated by the long temple axis, and each sacred place contained many such temples, because there were many heavenly bodies to be watched. The temple of Amen-Ra, if contracted for now, could not, I fancy, be built for less than 5,000,000 pounds sterling, and it might take ten or fifteen years to erect. But it simply had one outlook, one use.

Now, to carry on this method of observation and worship where the population was scarce, the best and cheapest thing to do would be to build a bank or set up a line of stones to represent a temple axis, or to build a circle to represent a sanctuary, and from its center to imitate various temple axes by sight-lines marked out by a stone or barrow at some distance outside the circle. Six such outstanding marks, each of stone set up in a day or two, would then replace, and quite effectually from the astronomical point of view, six majestic temples taking tens of years to build, and the elaborate system of avenues and cromlechs represented by all the temples at Thebes or in any other locality, however numerous.

Only the holy of holies as a dark chamber would have to go; the center of the circle would replace it as the priest's place. That was a matter for the priests, and had nothing to do with astronomy. In any case, *from the astronomical point of view*, what was done by the Theban priests by building all these majestic temples could be done by one circle with properly arranged outstanding stones, so that the circle represents a distinct advance over the idea connected with the avenues and the cromlechs.

We shall not, then, be far wrong in supposing circle building to represent a later development, and this view is strengthened by the fact that there are no circles in Egypt, where the avenue-cromlech system is most developed.

The next upshot of the inquiries arrived at, soon after I had measured several stone monuments in Cornwall and on Dartmoor, was that the directions indicated by the avenues, cromlechs, and circles with outstanding stones were certainly not helter-skelter. When they were classified it was found that only a small number of directions was used—that is to say, directions embracing sunrise and sunset throughout the year, and directions to the north or south parts of the horizon which the sun never reaches.

Next it was found that these directions were practically the same, and had the same uses, as those I had previously studied in Egypt—in short, that the British avenues and stone circles bear precisely the relationship to the Egyptian temples indicated above. The "clock stars" used in the British monuments were the precise equivalents of the stars in Ursa Major and Draco used by the ancient Egyptians, when

* Nature.

† In two instances of the dedication of the same temple to different stars at widely different epochs, the orientation theory tells us that the temple of Denderah was built either to observe the rise of the principal star in the Great Bear in 4950 B.C. or the principal star of Draco in 3100 B.C. or both; the inscriptions tell us that the temple was founded in the times of the Shemsu Heru before Mena, whose date, according to Budge's "History of Egypt," was 4400 B.C., and was afterwards restored by Pepi, whose date, according to the same authority, was 3233 B.C.

At Annu there was a restoration of an old temple by Usertsen (2433 B.C.). The story is told in a roll still extant. The theory tells us that, as at Denderah, this restoration was undertaken to watch the rise of the principal star of the Dragon in 2500 B.C., the restored temple having been originally founded to watch the rise of the principal star of the Great Bear in 5200 B.C.

we take the difference of latitude between Egypt and Britain (25 deg.) and the effect of the precessional movement on the declination of the star into account. The same may be said of the "morning stars" they employed.

These "morning stars" were of very great importance. We are familiar with them from Bible references. These were stars which rose about an hour before the sun itself rose. In the earliest time there were sacrifices, and the morning sacrifice was a very elaborate affair, which required about an hour for its preparation, so that unless the priest could get some idea of the time of the actual sunrise some hour or so before the sun itself rose, he might go very wrong, and be either too early or too late at the moment of the rise of the great luminary. When the alignments to the places of the sun at different periods of the year were investigated, another conclusion of first-rate importance was arrived at.

At first the all-important positions of the sun, as indicated by the alignments, were not the solstices or the equinoxes, but at intermediate points when the sun occupied the declinations 16 deg. 20 min. N. and S. The year was thus defined by the sun's stations in May, August, November, and February.

This I have called the "May year," a vegetation year. I think it must be acknowledged that one of the most important results of the new method of looking at monuments has been the demonstration of the existence in early times in Britain of a year which began in May or November and ended in November or May; and this, one of the teachings of the monuments touching our early history, will in the future greatly help folklorists and others interested in antiquity and the dawn of the so-called Celtic literature. There is now no doubt, after the researches of the Rev. J. Griffith, that the Welsh Gorsedd circle brings before us, in stone, traditions of a time when the May year was in vogue.

The reason that we had that year before we had the real astronomical year, which works from the solstices in June and December to the equinoxes in March and September, is that the worship and use of the sun began before the length of the year had been made out, and that the worship was at its highest in Babylonia and Egypt at the time the sun was giving to us the most that it could give—that is to say, the harvests of the fruits of the earth.

The earliest temple that I know of directed to the May sun is at Memphis, which must date from some 4,000 years B. C., and it may well be that at that time little was known about the length of the year, because it looks very much as though the Theban cult was established at Thebes as opposed to Memphis some 2,000 years after the date I have mentioned, simply because the Egyptian astronomers had then found out the length of the year and had begun to use it.

One reason why they reckoned their year from solstice to solstice, which is what we do now, was probably because at the stolstice the sun rises at the same place on the horizon for three days, whereas the determination of the exact position of the sun on May 6 or March 21 is a matter of difficulty as compared with the determination of the solstice. When Mr. Penrose and myself were making observations, we were led to the belief that the present Stonehenge, with its complete sarsen stone circles, is relatively a modern affair, and that there had been at Stonehenge, long before the sarsen circles were erected, an old temple directed to the "May year." I have since found in many cases traces of the "May year" anticipating the solstitial year. The solstitial cult in Britain followed the "May year" cult, just in the same way as in Egypt the solstitial cult at Thebes followed the "May year" cult at Memphis and Heliopolis.

In relation to the sun's seasonal times, then, we find temple axes, avenues, and circles with outstanding stones indicating the direction in which sunrise or sunset was to be looked for at the critical times of the year—that is, the beginning of May, August, November, and February, dealing with the May year, and the longest and shortest days of the solstitial year.

In connection with these solar alignments, evidence is forthcoming that in some cases warning was given of the chief festivals by erecting stones marking the sun's sunrise place from some twenty-one days before they occurred. It is thus possible that the structure of the Roman calendar with the 21 *dies ante calendas* and the ecclesiastical period of Lent, which was originally of three weeks' duration, may have had their origin in the stone-circle practices.

The next main conclusion derived from the work has to do with the dates of erection of the various monuments. With regard to these, I limit myself now to Britain.

The determination of dates is rendered possible by the change of the declination of the sun at the solstices and of stars, brought about by astronomical causes into which we need not now enter. This declination, indeed, is constantly changing, but we have, thanks to the researches of Stockwell and Dr. Lockyer, tables of the declinations of the solstitial sun and of the principal stars, century by century, as far back as 4000 B. C. It is fortunate that, to determine the declination to which the direction of each monument corresponds, very simple observations alone are required. It is as well to recapitulate them here. First, the exact direction of the temple axis or avenue, or of the outstanding stones or barrows, as seen from the circle, in astronomical terminology their azimuth, is obtained by measurements made at the actual monument or on the 25-inch Ordnance map. The angular height of the horizon on this line has next to be measured. With these data and the latitude, the declination (that is, the distance from the equator) of the body observed along the sight-line indicated can be calculated. The solar group of monuments practically does not help us with regard to dates, for the reason that the change in the position of the sun every succeeding 1,000 years is very small, but the change in the position of the stars every 1,000 years, or even 300 years in some cases, is considerable, so that in the matter of dates we are thrown back almost entirely upon the stars. Still, there is one solar temple so perfectly arranged at Stonehenge that it has been possible to suggest the date for it within something like 200 years; the measures of that, quite independently of any view determined from other considerations, gave us about 1680 B. C. for the erection of the solstitial sarsen stones at Stonehenge.

Observations have been made at a large number of monuments in Britain during the course of the last three or four years, by the help of a great many friends in different regions, who find it a very pleasant occupation for their holidays. Already something like 140 or 150 alignments of avenues or of cromlechs, or of outstanding stones, have been measured, and 113 results have already been tabulated. These are as follows:

Sun.	
May	15
November	9
Summer solstice	17
Winter solstice	11
Stars.	
North clock stars Arcturus	24
North clock stars Capella	13
South clock stars α Centauri	6
Warning stars Pleiades	16
Warning stars Antares	2
Total	113

It will be seen how overwhelming the evidence is becoming that blind chance had nothing to do with the setting out of the various alignments, how they all fall into a few definite groups, and how the large mass of evidence now accumulated entirely justifies the conclusions derived from those first placed on record.

With regard to the dates given later on, all are approximate only; there is nothing perfect about them. The Welsh Commission and the other commissions will, I hope, make measures, using solar instead of magnetic methods, and determine the height of hills in minutes instead of half degrees, and if they do that these dates will certainly be changed, though they cannot be changed very much.

I have already shown that the May year and the solstitial year had temples sacred to them in Egypt. I may now add that in the Egyptian temples we found one set for the northern stars, the equivalents of Arcturus and Capella, and another set for the southern stars, among them α Centauri. One of the most recent results of this inquiry has been that we have found a number of avenues, not circles, in Brittany and in different parts of Britain, not in Cornwall, the equivalents of the Egyptian temples aligned to the southern stars. The probable alignment corresponds with the southern star α Centauri. There is the Challacombe avenue on Dartmoor, the Borobridge avenue near Harrogate, and others at Avebury and Shap.

Now if we deal with the "clock stars" in order of date, α Centauri comes first, B. C. 3600-2700. This is followed a thousand years later by Arcturus, B. C. 2600-1350, and Capella, B. C. 2250-1250. In all these cases there is a complete series of dates from one end to the other. Now these are the "clock stars."

Coming to the warning stars, it will be noted that the Pleiades were observed rising, and Antares setting, heliacally—that is, about an hour before sunrise. The dates are: Pleides, B. C., 2120-1000; Antares, B. C. 1720-1310.

We see that about the same dates are involved as those found in connection with the northern "clock stars," and this, of course, strengthens the view that we are really dealing with alignments set out for a definite purpose at a definite time. The story, then, is that astronomer-priests familiar with Egyptian methods began work here by building avenues in different parts of Britain about 3600 B. C.

The star employed as a "clock star," then, was α Centauri, one of the stars used in Egypt. This cult was succeeded by another, in connection with which circles were introduced and northern "clock stars" were used. This was the chief cult in Cornwall from 2600 B. C. onward.

If we accept the dates thus astronomically revealed by the stellar alignments, several interesting consequences follow. The British circles were in full work more than a thousand years before the Aryans or Celts came upon the scene, if the time of their arrival favored by archæologists is anything like correct. Stonehenge began as a May temple—a British Memphis—and ended as a solstitial one like that of Amen-Ra at Thebes. Another conclusion is that, whatever else went on some four thousand years ago in the British circles, there must have been much astronomical observation and a great deal of preparation for it. Some of the outstanding stones must have been illuminated at night, so that we have not only to consider that the priests and deacons must have had a place to live in, but that a sacred fire must have been kept going perpetually, or that there must have been much dry wood available. The question, then, is raised whether dolmens, chambered barrows and the like were places for the living rather than for the dead, and, therefore, whether the burials found in some do not belong to a later time.

The determination of dates, in conjunction with the conclusions arrived at concerning the various kinds of monuments, opens up another point of view which possibly in the future may lead to fruitful inquiries.

Why have we in different temple regions such great differences in the relative numbers of avenues, cromlechs, and circles, the extreme case being that only one class is represented?

When the order of the evolution of the different classes of structure is settled, the geographical distribution of them may lead us to further conclusions. The tremendous development of avenues in Brittany and in some parts of Britain where circles are almost entirely absent suggests that a people came here who knew nothing about circles, but did know much about avenues. These in Britain to which I refer were on a scale almost rivaling that of the Brittany avenues. The avenue at Shap was more than a mile long, that at Borobridge was nearly a mile long, and some of the stones were more than 20 feet high. The avenue at Challacombe must, when complete, have been a most stupendous monument. Further, the builders of all these worshiped a southern star; they were not miners, they did not go to Cornwall, and there is a difference of more than 1,000 years in the dates derived from these avenue builders and from the circle builders of Cornwall and South Wales.

It may be worth while to refer briefly to some of the objections still urged against the orientation theory by those who are either unwilling or incompetent to test it by actual observations.

One is that there are so many stars that any alignment is certain to hit the rising or setting place of one of them. The fact that, with all the host of heaven to choose from, only six stars were used, and those among the brightest visible in these latitudes, and, further, that a good reason has been found for using those particular stars, is a strong argument against this objection.

Another objection made is that the theory demands a much greater knowledge of astronomy than the early temple-builders were likely to possess.

Those who put forward this objection entirely forget the conditions under which early man lived and moved and had his being. The conditions now are so different that we must not be astonished at the early peoples apparently behaving like astronomers; they could not behave like any other kind of men. The movements of the sun by day and the movements of the stars by night were the only things they could learn about, and it was imperative that they should learn about them.

People without almanacs and without any idea of the length of a year would find life absolutely impossible, at all events from the agricultural operations point of view, unless they could get, somehow or other, a general means of telling when they should plow and sow and reap. That depends upon the time of the year, and the time of year is written out very large indeed to anybody who will take the trouble to note where the sun rises. Similarly, if these people wanted to know about the flow of time at night, they would be under very great difficulties. In the first place, they had no clocks, so that unless they could get some idea of the time at night by observing the stars they would be entirely out of it so far as the lapse of time during the obscured part of their lives was concerned.

It no doubt is difficult for the average Englishman of the present day, unless he happens to be a sailor, to picture to himself a townless world without artificial light and any useful purpose served by looking at the sun by day or the stars at night. Calendars, almanacs, clocks, and watches have done away with the necessity of using his eyes in this direction, and the modern priest, like the modern layman, though

he prates about the heavens declaring the glory of God and the firmament showing His handiwork, too often does not know that the sun rises to the eastward, and, if he does, he imagines that it rises in the same place all the year round; *natura rerum* does not interest him.

The ancient priest need not have been a profound astronomer to build the monuments, which were simply calendars. I do not mean to say they were calendars and nothing more, but they were, from an astronomical point of view, simply calendars, enabling people to know and recognize from past experience the different parts of the year by the place of sunrise or sunset, and they were also night dials, enabling them to differentiate between the early and the late hours of the night.

In my inquiry I have not confined myself to the astronomical side of the question. I have tried to dip into the folklore and tradition already garnered in relation, not only to the sacred stones, but to the sacred wells and sacred trees.

From what I have learned I am convinced that much light will be thrown on both when an attempt shall have been made to picture what the lives of the first British astronomer-priests must necessarily have been.

It is interesting to note that, while the astronomical side of the inquiry suggests a close connection with Egyptian thought, the folklore and traditions, when studied in relation to the monuments, indicate a close connection between the ancient British and the Semitic civilizations.

I do not wish for one moment to suggest that the work in all these various kinds of monuments was limited to practical astronomical purposes. Our traditions render that view impossible. There was worship in its highest forms, perhaps in its lowest forms; there was magic, there were all sorts of things going on in relation to the wants of the people, and it was because there were some people who did know all that was required to meet general and special needs, including their agricultural wants, that they eventually became priests, because they were the men who knew, and that I believe to be the origin of priestly power throughout the world.

This work, if subsequently confirmed by other investigators, has the double advantage of supplying us pretty accurately with the date of erection of the monuments and of indicating the methods of observing the movements of the sun and stars employed in Britain in prehistoric times; and if risings and settings were so abundantly utilized—for utility as well as priestcraft was certainly at the bottom of it—in Britain four thousand years ago, the remarkable testimony to the knowledge and wisdom of the "Druids" given by Cæsar and Pomponius Mela two thousand years nearer their time is now seen to be amply justified.

"Multa praeterea de sideribus et eorum motu, de mundi magnitudine, de rerum natura, de deorum immortalium vi ac potestate disputant et juventuti tradunt."—Cæs. De Bello Gallico, VI., c. 14.

"Hi terrae mundique magnitudinem et formam, motus coeli ac siderum, ac quod dii velunt scire, profitentur."—Pomp. Mela, II., c. 2.

The "Druids" of Cæsar's time were undoubtedly the descendants of the astronomer-priests some of whose daily work has now perhaps at last been revealed.

A wave-control method devised by Paul Mortier is based upon the use of rapid or slow signals in order to operate the different devices. Each of the receiving devices is adjusted so as to respond when the signals have a certain rate. Such signals are made up of Morse dots placed close together, or rather the waves which are represented by such dots. The dots can be made to follow each other rapidly or at slower rates, and for each of the determined rates there is one of the receiving instruments adjusted to respond. Such an instrument then acts as a relay so as to close a local circuit and produce, for instance, the steering of a torpedo. A number of receivers are thus placed together for producing the different effects. Below a certain rate, none of them will respond. By raising the speed we cause the first receiver to act, then by increasing it still further, the second one will work, and so on. Another apparatus for wireless control uses two revolving dials, each carrying a set of contact points. The hand of the sending dial is advanced by one point, and this causes a wave-operated ratchet on the second dial to advance its arm also by one point, and so on. However, the latter arm is kept upheld from the surface by a dash-pot device which acts as a time retarder, and as an impulse is given to the dash-pot when the ratchet passes each point, the arm is kept lifted and can never descend upon the dial while revolving, except when it is allowed to remain stationary for say ten seconds. The dash-pot then allows it to descend, and it makes an electric contact at this point on the dial. To make the contact at any given point, the operator passes rapidly over the dial and then stops the arm at the point required.

ENGINEERING NOTES.

Bolivian purchases of mining machinery depend on the development of the tin, silver, copper, and gold mines. The introduction of modern machinery is likely to be the result of the railway building which is now going on, since this will reduce the expenses of transportation, and render accessible regions in which heretofore the mines have been worked after the old methods and with limited means, on account of the very heavy charges incurred in carrying the products of the mines. According to the United States special agent in Bolivia, the tin mines are likely to furnish the best market. The Bolivian production in 1907 was approximately 16,000 tons of pure tin, slightly less than for the previous year.

The first bituminous coal mined in the United States, says the United States Geological Survey, was taken from what is usually termed the Richmond Basin, a small area in the southeastern portion of Virginia, near the city of Richmond. This basin is situated on the eastern margin of the Piedmont Plateau, 13 miles above tide water, on James River. It lies in Goochland, Henrico, Powhatan and Chesterfield counties. The coal beds are much distorted, and the coal is of rather low grade when compared with that from other districts with which it has to come into competition. The occurrence of coal was known in the Richmond Basin as early as 1700, and in 1789 shipments were made to some of the northern States. In 1822, according to R. C. Taylor, the production amounted to 48,214 gross tons. At present what little coal is produced in this field is for local consumption only.

Prof. Glasenapp has made a study of gypsum and plaster, which corrects certain erroneous ideas of the formation, constitution, and properties of ceiling plaster, and emphasizes the difference between it and modeling plaster. The character of the product obtained by calcining gypsum varies greatly with the temperature employed. The products obtained by heating to various temperatures may be classified as follows: I. Plasters which crystallize and change form on setting with water: *a.* Raw plaster, or ground gypsum, a dihydrate containing 2 molecules of water; *b.* 225 deg. F. demi-hydrate containing ½ molecule of water, modeling plaster; *c.* 225 to 338 deg. F., chiefly demi-hydrate, modeling plaster; *d.* 338 to 392 deg. F., the same, more or less dehydrated, modeling plaster; *e.* 392 to 482 deg. F., contains very little water and sets slowly, at first forming the demi-hydrate; *f.* 482 to 572 deg. F., contains only traces of water and sets slowly. II. Plasters which crystallize and change form with solution of alum, but not with pure water: *g.* 572 to 1,290 deg. F., entirely free from water; *h.* 1,380 to 1,470 deg. F., anhydrous and partly granular, commencement of formation of ceiling plaster. Varieties *g* and *h* harden slightly, or not at all, when mixed with pure water. *i.* 1,470 deg. F., ceiling plaster with imperfectly developed grains; *k.* 1,650 to 1,830 deg. F., ceiling plaster with normally formed grains; *l.* 1,830 to 2,550 deg. F., ceiling plaster with grains increasing in size and hardness, and with increasing proportion of basic sulphate, as the temperature of calcination is raised. Varieties *i*, *k*, and *l* set slowly with water, without undergoing expansion or alteration of form.

In a note presented to the French Academy of Sciences by René Arnoux, the propulsive power of an aerial propeller is defined as the product of the velocity of translation by the thrust in the direction of the axis. The thrust can be measured without difficulty when the airship is kept at a fixed point, but the law which connects the thrust with the velocity is not known. The important factor is the effective thrust, which is exerted when the propeller moves rapidly through the air. This cannot be measured directly, but it is possible to measure the equal thrust exerted when the propeller is operated at a fixed point, and an air current which moves with the assumed velocity of the airship. After describing his experiments and the values thus obtained for the thrust and the propulsive efficiency, M. Arnoux adds that, in current practice, aerial propellers are designed to absorb at a fixed point the whole power of the motor. But the pressure of the air upon the propeller blades and, consequently, the couple opposed to the rotation of the propeller, diminish as the velocity of translation increases. Hence the velocity of rotation will increase, exceed the velocity calculated for the maximum power of the motor and, possibly, wreck the propeller. The object sought by the constructor should be, not to obtain an efficiency higher than two-thirds, but rather to adapt the dimensions of the propeller to those of the airship and to diminish the resistance opposed to the forward movement of the latter, so that its normal speed shall be, as nearly as possible, two-thirds of the maximum velocity which its propelling apparatus can impress upon it. In general, it is advantageous to employ propellers of great diameter and large blade area. The small power required to propel the Wright aeroplane results from the employment of two propellers of large diameter and area, rather than from the shape of the blades.

TRADE NOTES AND FORMULÆ.

Alger Metal (métal d'Alger).—White metal alloy for table bells, etc., consisting of 94.5 parts of tin and 5.5 parts of antimony.

To Restore Brass Articles.—The brass surfaces are freed from dirt in hot soda lye; if bronzed, they are dipped, as directly taken from the lye, into very dilute sulphuric acid solution and rinsed off in clean water. Then they are pickled in a mixture of 75 parts nitric acid, 100 parts sulphuric acid, 1 part common salt and two parts of hard lamp black (German: Glanzruss), rinsed off, polished or burnished, and to prevent oxidation, coated with colorless spirit varnish, which is best accomplished in a slightly warmed condition. If it is desired to make the articles particularly attractive, they are first pickled (after the boiling) in 200 parts of nitric acid, 2 parts hard black and 1 part common salt, and immediately afterward in 75 parts of nitric acid, 100 parts sulphuric acid and 1 part common salt. The first mixture is the preliminary dip, the latter the regular bright dip. After polishing, etc., the articles can be coated with gold varnish, by means of a soft brush of marten or fish otter hair, or —in the case of smooth articles—by means of a wad of cotton, after heating the articles. The latter operation, however, requires thorough practice.

Matt Dipping of Brass Articles.—The matting or deadening can be effected by various methods. Every bright dip acts as a matt dip, if the articles are exposed, for a prolonged period and at increased temperature to the effects of the dip. The deadening or frosting is, however, made more effective when zinc vitriol is added to the pickle and the matting will be more marked the more white vitriol (sulphate of zinc) is added. A good matting bath is produced by pouring a solution of 10 parts of zinc vitriol in 50 parts of water, to the cooled mixture of 3,000 parts of nitric acid of 36 deg. Bé., 2,000 parts sulphuric acid of 66 deg. Bé., and 15 parts of common salt. According to the shade it is desired to attain, the articles are allowed to remain 2 to 10 minutes in the liquor, from which they emerge with a dull, earthy appearance, they are quickly passed through a clean brightening pickle that imparts to them a dull brilliance, and are then quickly rinsed in abundance of clean water. To obtain a matt-grained—granulated—surface by dipping, the following mixture, consisting of 1 part by volume of saturated solution of bichromate of potash in water and 2 volumes of concentrated hydrochloric acid, may be recommended. In this mixture, the brass articles are allowed to remain for several hours. They are then rapidly passed through the "bright dipping" bath and rinsed in plenty of frequently changed water.

Chemical priming paint, for all wood paints, marble, and floors. Place well washed ocher or chalk in a roomy kettle and pour in vinegar until a paste is obtained. The kettle is placed on the fire and at the same time a smaller pot, which contains finely crushed alum, tartar, and vinegar, these salts dissolve in the heat; to 1,000 parts of ocher we allow 50 parts of alum and 10 parts of tartar. As much vinegar is added as will submerge the mass. When the priming paint boils and the alum is well dissolved, we pour into the yellow earth boiled-down glue with which some ox gall has been boiled, adding sufficient glue to leave the mass fairly fluid. Then the alum, with the vinegar and some linseed oil varnish, is added, after which the mixture is allowed to boil well for 6 to 8 minutes. To 10,000 parts of varnish, we reckon about 1,500 parts of glue and to 20 pounds of undissolved glue, one ox gall. The priming to be employed for the exterior painting of houses on Portland cement, so that the oil paint will not be destroyed by the niter, also for damp walls, is made as above described, only, in place of ordinary vinegar, use wood vinegar and double the quantity of alum and tartar. Otherwise proceed as above described, only, when the vessel is removed from the fire, pour in fuming sulphuric acid, allowing for 7,000 parts of color, 30 parts of sulphuric acid. For use on damp walls: If the mortar is still solid, the priming may be applied to it in two coats; if the mortar has been badly injured by the moisture, it should be completely removed and the priming applied to the naked stone.

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